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The Effect of Indoor Radon on Human Health, Review

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Abstract

Radon-222 is a radioactive gas that generally occurs in the Uranium-238 decaying chain. The existence of it in the natural world is connected chiefly with trace levels of ^{238}U and its parent, radium-226, within soil, rocks, and groundwater. Inhaling of the short-lived radon daughters is predicted to produce around half of the effective doses of the environment. As a result, radon is the most commonly studied subject concerning environmental radioactivity research. Elevated radon levels in the interior of buildings pose a significant health risk to humans. Radon products are well known as the cause of lung cancer along with various types of cancer. Radon has been utilized as a tracer in the research of atmospheric transport processes. Radon has also been used in several other fields, including meteorology, water science, and medicine. The article overviews indoor radon in the environment and illustrates the effect of radon and its progeny on human health.

Keywords: Indoor Radon, Radon Progeny, Health Effect, and Cancer

Introduction

It is a constant and inevitable risk to life on earth for humans to be exposed to ionizing radiation from cosmic rays or NORM, which indicates naturally occurring radioactive materials [1]. NORM is present in food, water, and the atmosphere. The source of most natural radiation is radon, a radioactive gas with the molecular formula Rn [2]. Radon is a radioactive, colourless, odourless, tasteless noble gas naturally occurring in the soil as a byproduct of uranium or thorium indirect decay. It was initially found by F.E. Dawn in 1900. Consequently, it is undetectable by the human senses [3]. At 0 °C and 1 atm, the density of radon gas is 9.73 g/l, making it 7.5 times denser than air. It is highly water-soluble and becomes less so as the temperature rises, but it is also very easily removed from it. Radon, and also with He, Ne, Ar, Kr, and Xe, is a member of the noble gas family often recognized as inert gases. These do not have any naturally occurring chemical compounds because they are not chemically active [4]. Radon contains three radioisotopes, ^{222}Rn which called radon ($T_{1/2}$ 3.82 days), ^{220}Rn that called thoron ($T_{1/2}$ 55.6 seconds), and ^{219}Rn called actinon ($T_{1/2}$ 3.6 second), which belong to the natural decay series of Uranium-238, Thorium-232, and Uranium-235, respectively. When released into the open air, radon evaporates quickly, but it can be concentrated and accumulated to levels detrimental to the built environment. Because of its relatively long half-life and availability of parents ^{238}U in the earth's crust, ^{222}Rn has the most significant impact on human health compared to the other two isotopes [5]. The primary type of radiation emitted due to radon decay is α-particles. Because of their high relative biological efficacy (RBE), α-particles can cause severe biological harm to exposed tissues despite limited tissue penetration ability. The decay of Rn progeny emits β and γ rays as well. However, RBE is small when compared with α-particle ionization. α-particles comprise a helium nucleus (two protons and two neutrons) may accumulate much energy while moving through a substance. It is explained that β-particles (electrons) and γ-rays (photons) have high-line energy transfer (LET). Because of their high LET categorizing, α-particles were more biologically significant than β or γ rays, interacting more quickly with DNA and causing oxidative damage from radiation disintegration. Generate. Tissue places and kinds of cells within a crossable depth of alpha particle exposure are particularly vulnerable to biological harm [6].

The Indoor Radon and Its Progeny

All decay products of the 238U series were solid elements except radon, a radioactive noble gas. Rn decayed into a sequence of short-lived radioisotopes called the progeny or daughter of radon: 218Po, 214Pb, 214Bi, 214Po, until reaching stable lead

206Pb. Radon can be found in all soiland rocks, both indoors and outdoors. Because of continual dispersion and dilution, Radon and its progeny seldom reach high levels outdoors. Indoors, however, insufficient ventilation can allow Radon and its daughters to accumulate to orders of magnitude higher levels than outdoors. Radon can be found in nature in variable quantities on soil and rock and depends on the content of the decay product of the ^{238}U series [7]. All decay products of the ^{238}U series were solid elements except radon, a radioactive noble gas. Rn decayed into a sequence of short-lived radioisotopes called the progeny or daughter of radon: ^{218}Po, ^{214}Pb, ^{214}Bi, ^{214}Po, until reaching stable lead ^{206}Pb, as shown in Fig 1.

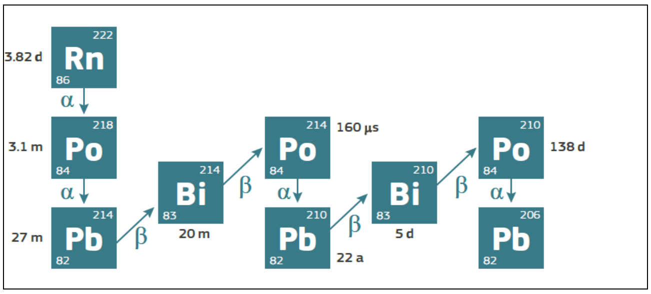

Fig 1: The Radon progeny in the Uranium-238 chain

Radon can be found in all soil and rocks, both indoors and outdoors. Because of continual dispersion and dilution, Radon and its progeny seldom reach high levels outdoors. Indoors, however, insufficient ventilation can allow Radon and its daughters to accumulate to orders of magnitude higher levels than outdoors. Radon daughters attach to the surrounding aerosol and, when inhaled, remain in the lungs, which can be supplied to the wall by releasing alpha particles. As a result, Radon daughters pose the most significant health danger, rather than Radon parents. Most exposures to Radon and its progeny occurred indoors due to a significant amount of time spent indoors and the elevated indoor levels of Radon relative to the outside level. Radon and radon decay products inhalation is the most significant cause of natural radiation exposure in the population, with countless lung cancer cases documented yearly [8]. Geological and geophysical circumstances, as well as atmospheric factors such as pressure and rainfall, significantly impact radon concentrations. Radon may escape into the environment as it flows through soil pores and rock cracks near the earth's surface. When a dwelling or another building exists, radon may travel into it and concentrate sufficiently to constitute a health risk. Research on natural radiation exposure shows that the problem of 222Rn and its daughters is widespread [9]. ^{222}Rn is the daughter of ^{226}Ra with a half-life of around 3.8 days, and when it decays emits α-particles with an energy of 5.49 MeV. The daughters of ^{222}Rn, such as ^{218}Po and ^{214}Po, also emit α-particles with energies 6Mev and 6.79 Mev. Radon's radio daughter products via ^{218}Po and ^{214}Po emit alpha particles. These daughters were charged and solid and also tend to attach to aerosols in the air. Most radon is exhaled when we breathe or inhale it with regular air. Still, its daughter products stick to our respiratory system's inner walls and membranes and continue to harm it over time because of its alpha activity [7]. According to the UNSCEAR Committee (1988), the annual effective dose equivalent for each individual experienced from radon and its progeny inhalation is 1.23 mSv, which means that 52% of the total radiation dose equivalent is obtained from natural and artificial radioactive origins, as shown in Fig 2. This means radon and its products constitute a significant portion of natural radioactivity in humans, in which 80% of people's time is spent indoors during daily activities [10].

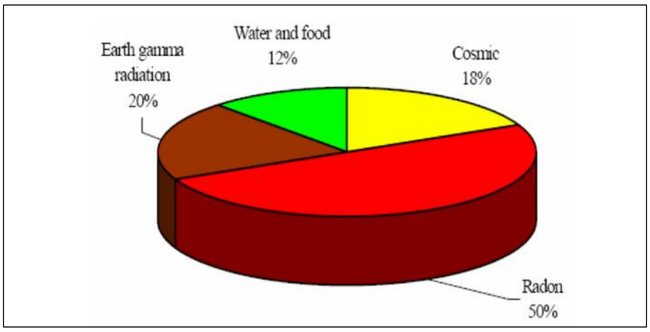

Fig 2: The contribution of the radon exposure to the total exposure of radiation

The Effect of Indoor Radon and Its Progeny on Human

Indoor radon is the leading cause of public exposure to ionizing radiation. Exhalation of earth and construction materials for ceilings, floors, and walls delivers 222Rn into the indoor air. The most common source of dwelling radon is soil gas intrusion. With insufficient ventilation in the rooms, the concentration of radon and its daughters increases. Indoor radon levels are affected by seasonal and diurnal variations, the type of building material used, and the ventilation system. Average annual radon radioactivity concentrations must be known to determine the possible dangers to building residents [11]. Radon's dispersion in nature is related to its immediate parent Ra-226, and it must be regenerated continuously to maintain a steady concentration. There are approximately less than 100 tons of radon in the earth's crust. Because of its chemical and physiological inactivity, radon gas is not a health risk when inhaled.On the other hand, the four nuclides that follow the uranium decay series Rn-222 constitute a health risk since they are metallic particles with a solid charge instead of a gas. The radon progeny have considerable activity, as evidenced by half-lives of 27 minutes or less. ^{218}Po and ^{214}Po were α-particles emitters. However, ^{214}Bi is the trustworthy source of ^{214}Po because it emits a particle nearly instantaneously. When not breathed, α-particles pose no health risk in surroundings because they are prevented within a few centimetres in the surrounding air [12]. When radon with short-lived daughters is breathed, alpha particles released by the accumulated decay products predominate the radiation dosage to lung tissue. These radionuclides, particularly those connected to tiny aerosols or those not attached, harm sensitive lung cells, increasing cancer risk. As a result, radon serves mainly as an origin of decay products that give a lung dose [13]. The body's exposure to ionizing radiation produces variations in sensitive cellular structures by directly transferring energy to the atoms of the cells, leading to a series of biological alterations caused by the immediate impact of radiation. Alternatively, it is recognized for interacting with water molecules in cells to form free radicals. These free radicals can travel long distances to interact with critical biological targets to produce intercellular damage. The second interaction is known as the radiation's indirect impact [2]. After smoking, Rn has been identified as the prevalent reason for lung cancer in the general population. When alpha particles are produced from deposited radon, the radon progeny may interact with cells in the lungs and cause damage to DNA. Cancer is widely considered to involve forming at least one intermediate cell growth that sustains some DNA damage, which can dramatically expand the cell pool. Commission Recommendation on protecting the public from indoor radon exposure provides a basis for further corrective action. These values equate to an average yearly indoor radon level of 400 Bq/m^3 in present structures and an annual average of 200 Bq/m^3 in future buildings. According to studies, the probability of lung cancer grows linearly with long-term radon exposure, and there is no danger of acquiring cancer. The increased risk is statistically substantial even when indoor radon levels are slightly below the suggested 200 Bq/m^3 level [7]. Assuming a life expectancy of 60 years, the estimated risk of lung cancer is 150 deaths per 100,000 inhabitants, i.e. 0.15. The Environmental Protection Agency (EPA) estimates that falling radon emissions in homes are responsible for between 5,000 and 15,000 deaths in the United States annually. State (assuming 1 death per 100 people per year). In August 1986, the EPA established health guidelines for how much radon gas was safe in the home. This is the first EPA law to address the spontaneous onset issue. The EPA has set a limit of 4 pCi/L as a radon level, which poses the same risk as half-day smoking. In addition, 8 pCi/L of radon predicts a 2% lifetime risk of developing lung cancer [12]. When inhaled, radon and its derivatives can travel through the lungs to the blood and body tissues, where they cause many types of soft tissue cancer, including lung, kidney and prostate cancer. Some radon dissolves in adipose tissue, and its byproducts can be transferred to the bone marrow. Cumulative doses can be high in the elderly and cause leukaemia. Radon has also been linked to melanoma and some childhood cancers. There was a positive association between coronary heart disease and radon exposure, and an increased risk of death from coronary heart disease was observed in miners with more than 1,000 work-months (WLM) cumulative radon exposure. Radon 218Po and 214Po descendants can be considered potential carcinogens in skin cancer development. We also found that breathing and smoking radon increases the risk of lung cancer. The proportion of radon orogenies in the lung radiation dose is two to three digits higher than that of 222Rn cancer. The risk from drinking water that contains dissolved radon is significantly lower than from inhaling radon. Radon-related health risks can be addressed by identifying areas with high indoor radon levels, developing strategies to reduce exposure, and implementing practical building improvements. Conduct research and provide education. Program for health authorities and the public. Recognizing the importance of radon as a public health problem, a large-scale national and international radon research program, the IAEA CRP Coordinating Research Program, "Radon in the Human Environment", was launched worldwide. More than 50 participating countries and the WHO International Public Health Radon Project (IRP) are on the radon exposure page. This project is a high priority for WHO's Department of Public Health and the Environment [14, 15].

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