



## **STUDY OF HARMFUL EFFECTS OF RADON AND OTHER NATURALLY OCCURRING RADIATIONS**

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### **ABSTRACT:**

*The past two decades have witnessed the rise of robotics as a challenging, emerging, developing and innovative field of research for academicians and industries. Robot can be defined as a machine that is capable of taking on a wide range of tasks with more autonomy and degree of freedom (DoF) than human beings. Presently, healthcare services and systems have become very complicated and include several entities that are marked by shared, distributed, heterogeneous devices, sensors together with information and communication technology or ICT. Internet of things (IoT) has integrated robots in things so that they connect with other things via internet. The application of robotics in healthcare facilities has guaranteed possibilities in the course of treating patients, increasing relief of clinicians and avoiding the patients as well as the healthcare staff. This chapter shows clearly the long terms benefits of people's existence in healthcare facilities such as e-health, medical emergency using robotics and IoT.*

**Keywords:** Medical robotics, Healthcare robotics, Assistive robotics, Rehabilitation robotics, Surgical robotics, Health design, Health information technology, Evidence based medicine.

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### **[1] INTRODUCTION**

Radiation present in the environment can originate from either natural sources or human activities. There are two categories of radiation: ionizing and non-ionizing. Natural background radiation, a form of ionizing radiation, is constantly present and impacts all individuals. Ionizing radiation possesses the capability to displace electrons from their orbit around atoms, disturbing the electron/proton equilibrium and posing a potential threat to cells. Certain radionuclides occur naturally in the earth's crust, whereas others are generated

in the atmosphere due to cosmic radiation. The radiation is constantly present in our environment, regardless of whether we are inside or outside, resting or working, dining or on the move. Cosmic rays and terrestrial sources contribute to natural background radiation, along with natural radioactive materials like radon found in the ground, building materials, and food and drinks. On the other hand, artificial sources of radiation include radioactive fallout from nuclear activities, medical applications of ionizing radiation, X-ray machines, particle accelerators, consumer goods, and transportation of radioactive materials.

## **[2] THE SOURCES OF NATURAL BACKGROUND RADIATION: -**

The United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) states that there are four primary origins of natural radiation: cosmic radiation originating from the sun and stars, terrestrial radiation from the Earth, and internal radiation present in all living organisms.

### **Cosmic radiation:**

The planet's outer layer is constantly attacked by space radiation. Typically, this comes from the impact of the Earth on high-energy particles from outer space (galactic radiation) and from solar radiation (primarily protons, particularly during solar flares). These particles engage with the nuclei in the air, leading to a chain of interactions and additional reaction by-products that make up the cosmic radiation on the ground. These particles are highly energetic. Certain ionizing radiations pass through the Earth's atmosphere and are absorbed by humans, causing exposure to natural radiation.

### **Radon and its Isotopes as Terrestrial radiation:**

The composition of the Earth's crust is a significant factor in terrestrial radiation. Low-level radiation in the environment can be attributed to radon and its byproducts, which are known to pose potential risks of human exposure. These elements are naturally present within the Earth's crust. The primary source of variation in natural radiation exposure is the inhalation of radioactive gases emitted by minerals present in soil and bedrock. Furthermore, water contains slight levels of dissolved uranium and thorium [3]. Essentially all air contains Rn<sup>222</sup> (Radon) and Rn<sup>220</sup> (Thoron), which are responsible for most of the doses are found in the uranium and thorium (U<sup>238</sup> and Th<sup>232</sup>) series, which vary widely. Estimated average concentrations in soil due to Uranium and Thorium series are 24 Bq/kg each [9].

Rn gas, which is chemically inert, is carried through the ground into homes through, gaps and other entryways in construction materials directly [6]. The rate at which the Rn builds up in the air above the ground and how easily it moves around in the soil, depends on the physical and environmental factors such as the water content of the soil type, among others. [1,9]. Rn<sup>226</sup> and Ra<sup>224</sup> give rise to the isotopes of Rn. Radon and thoron are an odorless and colorless radioactive gas that is produced by the decay of uranium and thorium. The high

concentration of these elements in uranium and other minerals has led to an increase in lung cancer cases among miners. Research indicates that the average lung exposure to  $\text{Rn}^{220}$  is about 25% of that from  $\text{Rn}^{222}$  progeny because of its faster decay rate. [8]. Radon's half-life is around 3.8 days, while thoron's half-life is approximately 55 seconds. Rn poses a health risk due to the alpha decay of its short-lived progeny,  $\text{Po}^{218}$  and  $\text{Pb}^{214}$ . Unlike the Rn gas, these nuclides are solid atoms that can adhere to surfaces such as airborne particles, room walls, and lung tissues. Inhaling radon can lead to lung damage and potentially cause lung cancer, as the alpha particles from its radioactive decay become trapped in the lungs and directly impact sensitive lung tissues.

### **Internal Radiation:**

All people have internal radiation. Naturally occurring radioactive elements are always present inside our body. Trace amounts of radioactive minerals enter our body through food we eat, water we drink and air we breathe. For instance, vegetables are usually grown in soil and groundwater that contains radioactive minerals. When consumed, these minerals lead to internal exposure to natural radiation. Some of the important elements found in the human body, such as tritium, potassium-40, and carbon-14, contribute significantly to our background radiation dose.

### **[3] NATURAL RADIATION DOSES:**

The energy absorbed by an individual from ionizing radiation is quantified in dose, typically measured in sieverts (Sv). This measurement is often expressed in either millisieverts (mSv), equivalent to one thousandth of a sievert, or microsieverts ( $\mu\text{Sv}$ ), which is one millionth of a sievert. The average annual effective dose from natural radiation worldwide is around 2.4 mSv, with Canada having a lower average of 1.8 mSv. However, in certain regions such as the Kerala Coast in India, the annual effective dose can be as high as 12.5 mSv. In the United States, the average annual radiation dose per person is 6.2 mSv. The dose can vary depending on the source of radiation, with some areas like northern Iran experiencing doses as high as 260 mSv per year due to geological characteristics.

### **Cosmic radiation:**

A recent study by Health Canada found that regions at higher altitudes receive more cosmic radiation. At sea level, the annual effective dose of radiation from cosmic rays is about 0.30 mSv, while at 2,000 m above sea level, a person would receive a dose of about 0.84 mSv annually. Additionally, flying in an airplane increases exposure to cosmic radiation, resulting in an average additional dose of 0.01 mSv per Canadian per year. Therefore, people who travel by air increase their exposure to radiation.

### **Inhalation of Radon and its Isotopes as Terrestrial radiation:**

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Radon gas is naturally produced by the earth's crust and can be found in the air we breathe. If inhaled, radon's four decay products can irradiate the lungs. The average annual effective dose of radon radiation worldwide is around 1.3 mSv. According to a recent survey by Health Canada, 93% of Canadian homes have radon levels below the current Canadian guideline of 200 Bq/m<sup>3</sup>. Radiation from natural sources in the ground can vary depending on the amount of uranium present in the soil. On average, the effective dose from this radiation is around 0.5 mSv per year. However, levels can be much higher in certain regions, such as reaching 260 mSv in Northern Iran and 90 mSv in Nigeria. In Canada, the highest estimated annual dose is approximately 2.3 mSv, as recorded in the Northwest Territories.

### **Internal Radiation:**

Our bodies are exposed to natural radiation from various sources such as the food we consume, the air we inhale, and the water we drink. Potassium-40 is the primary contributor to internal radiation (aside from radon decay). On average, the effective dose from these sources is around 0.3 mSv per year.

In 1999, the National Academy of Sciences (NAS) conducted a study on the causes of lung cancer and found that radon in indoor air is the second leading cause of lung cancer in the U.S. after cigarette smoking. The NAS reported that an estimated 15,000-22,000 Americans die every year from radon-related lung cancer. When smokers are exposed to radon, the risk of developing lung cancer is significantly higher than from smoking alone. Chart-1 compares lung cancer cases caused by radon to the incidence of other forms of cancer. The NAS also estimated that radon in drinking water causes an additional 180 cancer deaths per year, with almost 90% of those deaths being from lung cancer caused by inhaling radon released to indoor air from water. Only about 10% of the deaths were from cancers of internal organs, mostly the stomach, caused by ingesting radon in water.

Table – 1 provides the estimated yearly dose rate from natural sources in background areas [8].

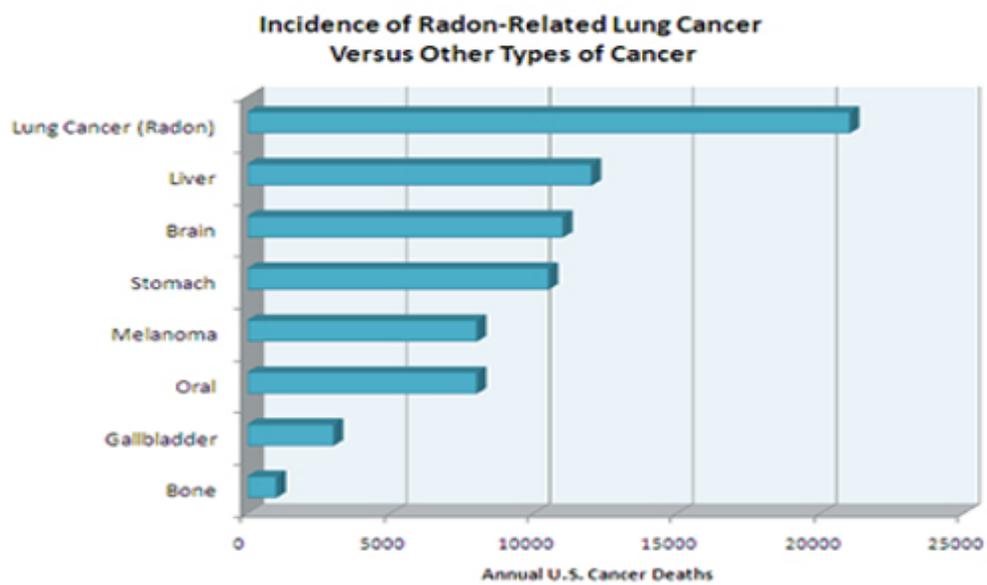
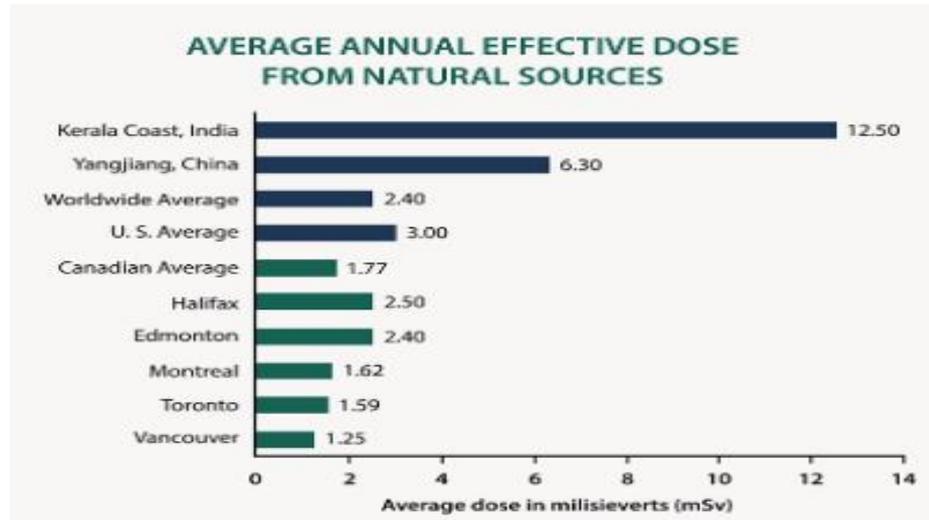
### **CONCLUSION:**

On average, we receive about 2.4 mSv/year of background radiation, but this can vary depending on the geology and altitude where we live. In some areas, the dose can range from 1 to 10 mSv/year, and in extreme cases, it can be more than 50 mSv/year [11]. The highest levels of background radiation are found in Kerala and Madras states in India, where around 140,000 people receive doses of over 15 mSv/year from gamma radiation and a similar dose from radon. Similar levels of exposure occur in Brazil and Sudan, with many people receiving up to about 40 mSv/year.

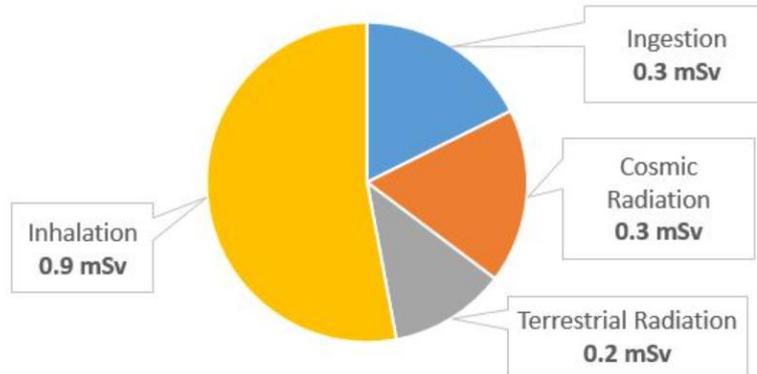
From the Table- 1, It is evident that 60% of the total dose received is attributed to Radon (Rn), Thoron (Th), and their products. Scientists have therefore made estimates to assess the incidence of lung cancer caused by Rn exposure in the general population. The risk of lung cancer increases with higher levels of Rn exposure. This health consequence is significant, and measures should be taken to minimize or regulate excessive exposure to Rn and its byproducts, as it requires greater attention.

**Table -1 Average annual effective dose of public due to natural background based on data from UNSCEAR [4] AND BEIR [5]**

S. No	Sources of Exposure		Annual average effective dose(mSv)		
			World Average (mSv)	Total Dose (mSv)	Typical range (mSv)
1.	Cosmic radiation	a) Directly ionizing and photon Component b) Neutron component c) Cosmogenic radionuclides	0.28 0.10 0.01	0.39 (0.16 %)	0.3 – 1.0
2.	External terrestrial radiation	a) Outdoors b) Indoors	0.07 0.41	0.48 (0.20 %)	0.3 – 1.0
3.	Inhalation of air	a) Uranium & Thorium Series b) Rn <sup>222</sup> c) Th <sup>220</sup>	0.006 1.15 0.1	1.26 (0.52 %)	0.2 - 10
4.	Ingestion of food and water	a) K – 40 b) Uranium & Thorium Series	0.17 0.12	0.29 (0.12 %)	0.2 – 1.0
	Total (natural radiation)		2.40	2.40	1.0 - 13



## Doses from natural background radiation



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