Investigation of the status of occupational and public radiation protection in institute of nuclear medicine and allied sciences: Khulna, Bangladesh

Goshtha Gopal Biswas[1], Md. Emran Hossain[1], S. M. Habib Uddin[1], Ashoke Kumar Paul[2], Karimul Hoque[1]*

1. Physics Discipline, Khulna University, Khulna-9208, Bangladesh.
2. Bangladesh Atomic Energy Commission.

*Author for correspondence (hoquekarimul@phy.ku.ac.bd)

Abstract

Radiation treatment is the key pathological concept for thyroid scan, thyroid uptake, bone scan, renal scan, and renogram, as well as various cancer therapies. Most of the ordinary people as well as the educated people of our country are not concerned about hidden radiation hazards in hospitals and radiation zones, which seriously affect not only public health but also employee health. In general, most people think that there will be nothing for them because they do not know anything about the damage of radiation. In some professions, like radiologists, radiology officers are highly affected by radiation because they cannot stay away from radiation. Since radiation has a dangerous effect on human health, we need to be concerned about radiation safety. Therefore, we gathered data from the Institute of Nuclear Medicine and Allied Sciences in Khulna by survey meter. From our experiment, we found that radiation spread throughout the center, which is (0.8-1.7μSv) the affordable limit.

Key Words: radiation, radiology officers, human health

Introduction

Radiation is energy that comes from a source and travels through space and may be able to penetrate various materials. Light, radio, and microwaves are types of radiation that are called non-ionizing. The word radiation comes from the phenomenon of waves radiating, meaning traveling outward in all directions from a source. Radiation has always been present all around us. Radiation can be ionizing or non-ionizing, depending on its ability to knock electrons out of the orbits of atoms when travelling through a medium[1]. The kind of radiation discussed in this study is called ionizing radiation because it can produce charged particles (ions) in matter. Ionizing radiation can cause damage to matter, particularly living tissue. Ionizing radiation is dangerous at high levels, so it is necessary to control ourexposure[2]. While humans possess no senses that can detect or feel radiation, radiation is readily detected and measured with instruments, and exposure can easily be calculated and monitored. Ionizing and non-ionizing radiation are divided according to their effects on substances [3].

Since we have concentrated ourselves on discussing ionizing radiation, we want to discuss some slots of non-ionizing radiation. Non-ionizing radiation may react with biological tissues through a variety of mechanisms. As far as we know today, non-ionizing radiation is unable to directly affect genetic material (DNA) because its energy level is not high enough to destroy the bonds between atoms and molecules of body cells[4]. Nevertheless, non-ionizing radiation may affect biological tissues through other mechanisms. The existence of a possible association between exposure to non-ionizing radiation (such as that emitted by mobile phones, domestic wireless phones, wireless communication networks, cellular base stations/antennas, electric grids, etc.) and the risk of developing diseases has been investigated for many years.

Research on extremely low frequencies (ELF), specifically in the frequency of electric grids, has also focused on the development of cancer, in particular leukemia in children, outcomes of pregnancy (miscarriages, birth weight), child behavior, cognitive function, hormones, neurodegenerative diseases, and heart diseases.

It is known that exposure to high-power non-ionizing radiation at certain frequencies causes heating of tissues, and that induced voltage gradients and currents may cause electrocution [5]. Aside from these known effects, the question of whether exposure to non-ionizing radiation is harmful to health is still controversial among scientists, and there are no unequivocal answers.

Most of the studies on radio frequencies have focused on the risk of developing cancer in its various forms, in particular brain tumors and tumors of the acoustic nerve or salivary glands. Additional health outcomes studied were the effects on fertility (e.g. quality and morphology of sperm cells), the brain (e.g. cognitive function, attention deficit disorders in children, brain development in babies), the heart and cardiovascular system (blood pressure, heart rate), the acoustic nerve, the saliva (secretion, composition, flow), blood lipid profile, obesity, neurodegenerative disorders (e.g. multiple sclerosis), headaches, and hypersensitivity to non-ionizing radiation.

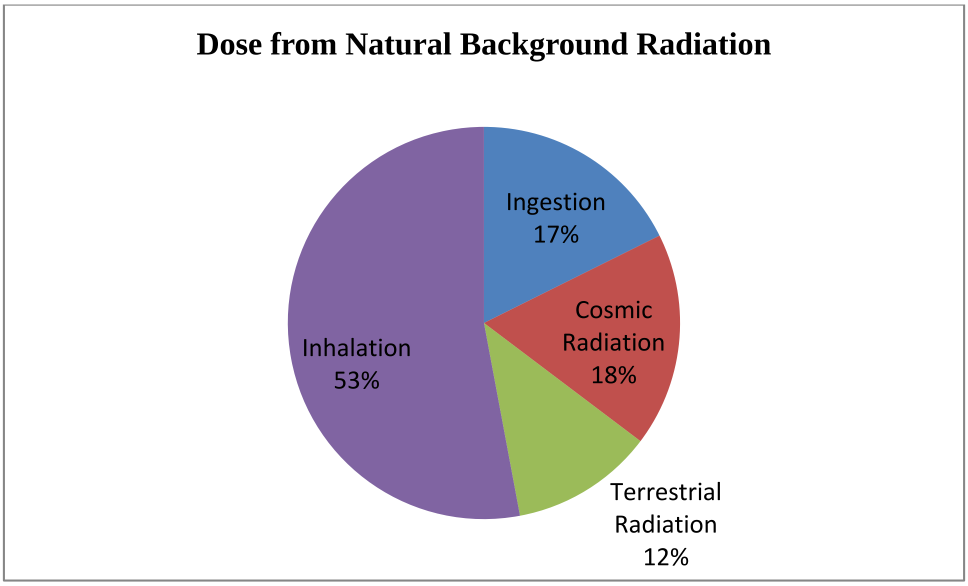
Now we concentrate ourselves to study ionizing radiation. Ionizing radiation is produced by unstable atoms. Unstable atoms differ from stable atoms because unstable atoms have an excess of energy or mass or both. Radiation can also be produced by high-voltage devices (e.g., X-ray machines).

Atoms with unstable nuclei are said to be radioactive. In order to achieve stability, these atoms give off, or emit, excess energy or mass. These emissions are called radiation. The kinds of radiation are electromagnetic (like light) and particulate (i.e., mass given off with the energy of motion). Gamma radiation and X-rays are examples of electromagnetic radiation[6]. Beta and alpha radiation are examples of particulate radiation.

Ionizing radiation causes ionization by breaking apart an electron from an atom or molecule. They are divided into two groups: particulate radiation with mass and electromagnetic radiation with the characteristic of photon energy waves. Alpha (α) and beta (β) particles, electrons, protons, and neutrons create the particulate ionizing radiation types. On the other hand, X-ray and γ-ray are electromagnetic radiation composed of high-energy photons with ionizing capability. They are substantially similar to each other in terms of their features, but their form of occurrence is different. X-rays are electron beams that occur outside the nucleus, while γ-rays are formed as a consequence of the ejection of excess energy from the nucleus by splitting during the stabilization of a radioactive core[6] . High energy ionizing electromagnetic waves can cause molecular changes that can lead to damage in biological tissue containing DNA and genetic material. In order to be able to achieve this effect, the tissue must interact with high-energy photons such as X-rays and gammarays[7]. Even within the limits of safety, radiation can have different negative effects on different people. For example, it is suggested that there is a relationship between low dose X-rays and goitre, breast and lung cancer, cataract, and leukemia[8]. It has also been accepted by the International Agency for Research on Cancer (IARC) and the World Health Organization (WHO) that X and gamma rays carry a risk of cancer for people (Cancer Council Western Australia, 2017). As a result, radiation areas are exposed as risky areas in terms of occupational health and safety. When examining the definition of occupational health as given by the World Health Organization (WHO), the physical, mental, and social well-being of employees must be kept at the highest level. As in all work environments, risk prevention strategies should be adopted in these areas. From this point of view, in order to minimize the risks, protection methods should be applied and protection methods should be determined according to the risks. Radiation protection rules can be grouped under three headings: distance, exposure duration, and shielding[9]. As one approaches the source of radiation, the dose rate (intensity) of the radiation increases inversely proportional to the square of the distance. Similarly, as the source is farther away, the dose rate decreases by the square of the distance between them. Secondly, the duration of exposure is also important. Radiation exposure is directly proportional to time. The shorter the exposure to radiation, the lower the negative effect on the employee's health. The last one in the protection rules is shielding. A shielding material must be placed between the sources. Depending on the energy of the radiation, the thickness of the lead material to be used in the shielding must be calculated. Ideal shielding should be 1 mSv/h in the working environment. In radiation fields where shielding is absolutely necessary, the instant dose rate is greater than 10 mSv/h[10]. In order to protect against radiation, the Turkish Atomic Energy Authority has introduced ALARA (As Low as Reasonably Achievable) measures regarding radiation safety in Turkey[8]. These measures suggest that the minimum possible doses should be obtained during studies done with radiation. That is, irrespective of the upper limits, it is necessary to arrange the working environment and working conditions according to the rules of radiation protection and to provide the conditions so that the dosage can be minimized. However, investigations have shown that the knowledge of health care workers is insufficient for radiation safety[11]. It is emphasized that radiology workers are negatively affected by radiation because personnel are not educated at a sufficient level[12]. The imaging centers in hospitals are among the areas where the risk potential is high as a working condition. The risk of radiation causes health problems such as thyroid, eye diseases, and hair loss, especially cancer types[13]. This makes the issue of employee safety for employees at imaging centers more important. By providing a level of employee safety information, it will be easier to minimize the harm for employees who have a lack of information in this regard. Thus, it is considered necessary to take the necessary measures to protect the health of the employees at the top level of these units so a more effective and efficient service can be provided.

How is radiation exposure measured?

In order to measure the health effects of low levels of ionizing radiation, scientists use a unit called the "Sievert" (Sv). The Sievert is used to represent both the risk of the effect of external radiation from sources outside the body and the effect of internal irradiation due to inhaled or ingested radioactive substances[14]. Because one Sievert represents a very large dose, the milliSievert (mSv) is commonly used in practice (1 milliSievert represents a thousandth of a Sievert).



Background radiation

Background radiation is the ionizing radiation that is naturally and inevitably present in our environment. It originates from a variety of sources. Sources include radiation from space (cosmic radiation), radiation originating on Earth (terrestrial radiation), and intake of naturally-occurring radionuclides through ingestion and inhalation. A person living in Canada can expect to receive around 1.8 mSv of background radiation in one year, while the average person world-wide can expect to receive 2.4 mSv[15].

Cosmic radiation

The Earth is continually bombarded by radiation coming from outer space, originating from the sun and other celestial events in the universe. Much of this radiation is absorbed in the atmosphere, but some will pass through and will be absorbed by humans. The radiation dose a person receives from cosmic radiation varies and will depend on location and altitude. This radiation is much more intense in the upper atmosphere, around the 10 km altitude typical for airline flight paths, and hence is of particular concern for airline crews and frequent passengers. During their flights, airline crews typically get an extra dose on the order of 2.2 mSv per year[16].

Terrestrial radiation

This is the radiation coming from the earth's crust due to the presence of naturally occurring radioactive substances such as uranium, potassium, and thorium. From deposits in rocks and sediments, these radionuclides may migrate into soil, water, and air. Some traces of these elements can also be found in building materials, and so exposure to natural radiation can also occur indoors[17].

Inhalation

Radon, a part of the uranium decay chain, is a radioactive gas that is odorless and colorless. Its presence in the soil varies largely by location. The only known health risk associated with high levels of radon in indoor air is an increased lifetime risk of developing lung cancer[18].

Ingestion

Some of the essential elements that make up the human body, mainly potassium and carbon, have radioactive isotopes that add significantly to our background radiation dose. Other radioactive elements are present in the food and drink that we consume daily. One example is bananas, which are naturally radioactive due to potassium-40, a radioactive isotope of potassium. Note that one should not avoid eating bananas because of this—for example, one would have to eat about 70,000 bananas to receive the same radiation dose as you would receive from one chest X-ray CT-scan.

Materials and methods

The study was based on the quasi-experimental model of quantitative research methods. In this experiment, our prime concern is to investigate radiation in different experimentally related areas like the adjacent flower garden, the corridor of the INMAS building, the free area, and radiation related rooms like the fume hood room, the Technetium illusion room, etc. For background radiation, before two hours of the experiment, we directed a survey meter to the object and took data from the screen[19]. In times of experiment, that means when isotopes are exposed to the patient and during the uptake, we again take the data from various objects. After two hours of the uptake, we again took data from the object.

Findings

Table 01: Radiation in μSv in outside of the working areas of INMAS

Content	Working Period	Without Working Period		
		Before	After	Average
Reception	0.24	0.23	0.23	0.23
Garden	0.21	0.21	0.20	0.21
Free Area	0.21	0.21	0.20	0.21

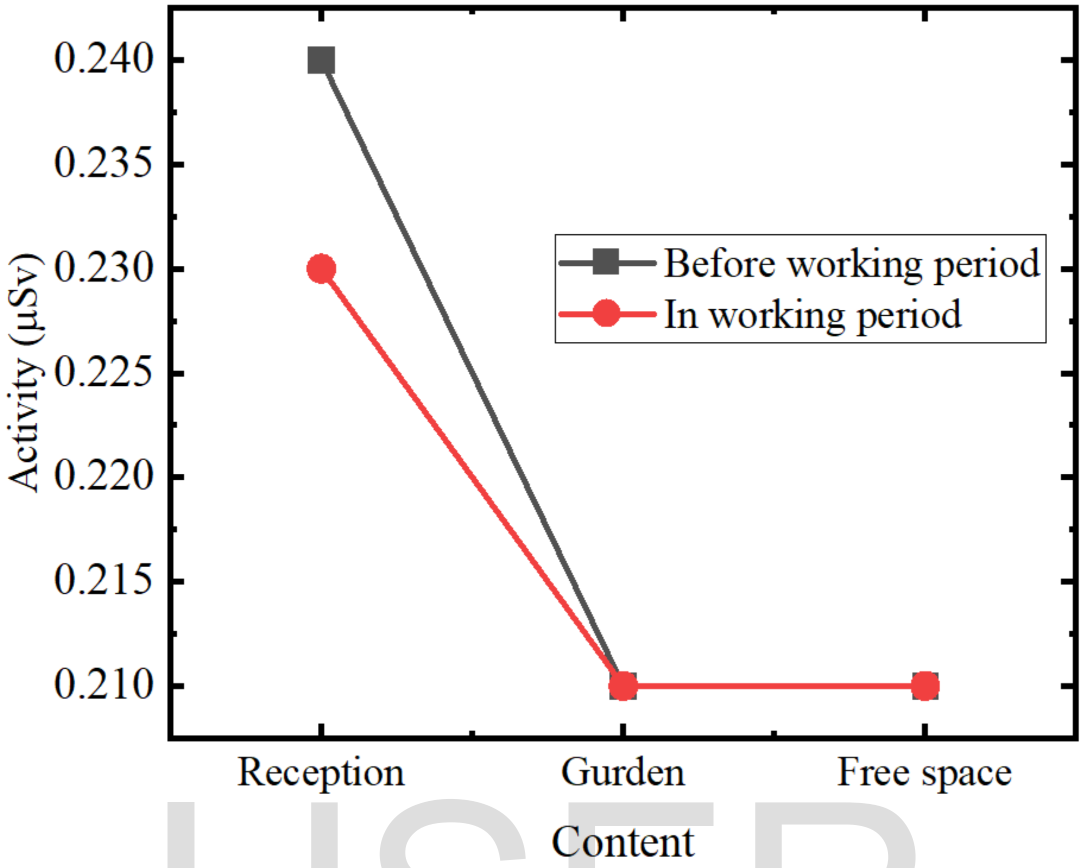


Figure 01: Activity in the different working areas outside of the working station

Table 02: Radiation in µSv inside the working areas of INMAS

Content	Working Period	Without Working Period		
		Before	After	Average
Basin	1.25	0.77	0.74	0.76
Working Table	0.83	0.51	0.69	0.60
Floor	0.54	0.37	0.37	0.37
Fume Hood Room (Background)	1.14	0.43	0.74	0.59
Fume Hood Room (F.H)	2.86	1.14	1.60	1.37
Thyroid Uptake	0.40	0.24	0.26	0.25
Outside SPECT	0.46	0.26	0.26	0.26
Under the stair	0.40	0.23	0.26	0.24
Single Head Gamma Camera Room	0.27	0.20	0.23	0.21
Thyroid Camera Room	0.31	0.21	0.26	0.24
Corridor(Patient waiting place)	1.43	0.24	0.30	0.27

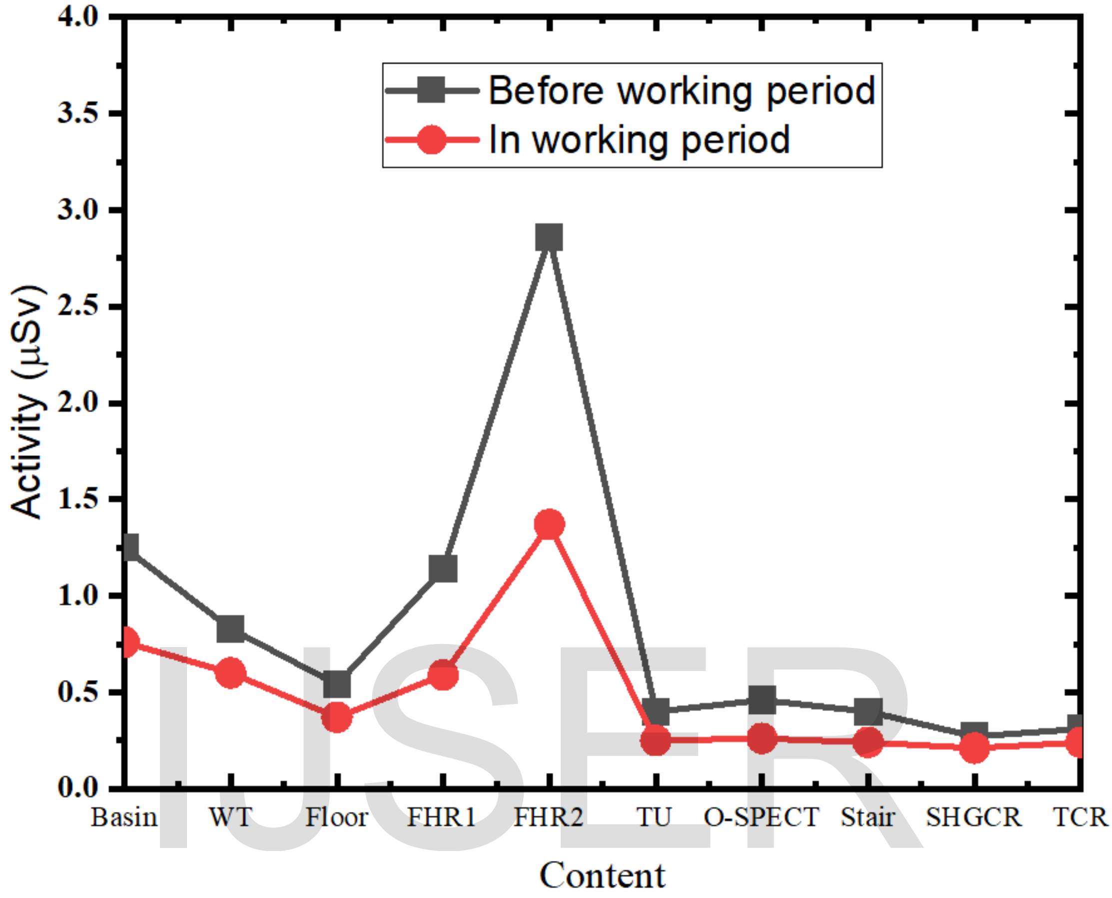


Figure 02: Activity in the different working areas inside the working station

According to the IAEA, the affordable level of radiation uptake for humans is 0.2-0.4 µSv/sec. In Table 1 and Figure 1, it's shown that at typical times, radiation outside the INMAS is nearly affordable. Due to experimental error or lack of consciousness, a little bit of radiation across the working areas crosses the affordable limit. But in times of experiment (Table 2), it has been shown that inside the working station, radiation crosses the affordable limit, which is 0.2 µSv to 3.0 µSv. From Figure 2, it shows that before and after uptake radiation has remained nearly affordable, but during uptake radiation remains very high. Since radiation has a dangerous effect on human health, it is necessary to control radiation spread throughout the room as well as the surrounding area. Some necessary steps, such as shielding, distance between the patient and the uptake object, and uptake time, should be considered. In INMAS, a separate room for patients should be confirmed.

Conclusion

Radiation treatment is the key pathological concept for thyroid scan, thyroid uptake, bone scan, renal scan, and renogram, as well as various cancer therapies. It has a tremendous effect on health and it will continue for several generations, safety parameters should be considered. We only took data for seven days. More data is necessary for making a concrete decision. Another important thing is that statistical analysis is necessary.

References

[1] A. F. Herrefile:///C:/Users/user/Downloads/KFK4706.pdfra Ortiz, L. J. Fernández Beaujon, S. Y. García Villamizar, and F. F. Fonseca López, "Magnetic resonance versus computed tomography for the detection of retroperitoneal lymph node metastasis due to testicular cancer: A systematic literature review," *Eur. J. Radiol. Open*, vol. 8, 2021, doi: 10.1016/j.ejro.2021.100372.

[2] S. Khan, M. Sayed, M. Sohail, L. A. Shah, and M. A. Raja, *Chapter 6 - Advanced Oxidation and Reduction Processes*. Elsevier Inc., 2018.

[3] J. L. Ryan, "Ionizing radiation: The good, the bad, and the ugly," *J. Invest. Dermatol.*, vol. 132, no. 3 PART 2, pp. 985–993, 2012, doi: 10.1038/jid.2011.411.

[4] P. Doll, "Neutron-Proton Scattering," 1990.

[5] K. -hoon. Ng, "Non-Ionizing Radiations - Sources, Biological Effects, Emissions and Exposures," *Proc. Int. Conf. Non-Ionizing Radiat. UNITEN*, no. October, pp. 1–16, 2003.

[6] A. Gonoskov *et al.*, "Ultrabright GeV photon source via controlled electromagnetic cascades in laser-dipole waves," *Phys. Rev. X*, vol. 7, no. 4, pp. 1–8, 2017, doi: 10.1103/PhysRevX.7.041003.

[7] G. Borrego-Soto, R. Ortiz-López, and A. Rojas-Martínez, "Ionizing radiation-induced DNA injury and damage detection in patients with breast cancer," *Genet. Mol. Biol.*, vol. 38, no. 4, pp. 420–432, 2015, doi: 10.1590/S1415-475738420150019.

[8] E. Senemtaşi Ünal, K. Geliş, and P. Baykan, "Investigation of awareness levels about the radiation safety of personnel working in the imaging units of the hospitals in Agri, Turkey," *J. Radiat. Res. Appl. Sci.*, vol. 11, no. 2, pp. 111–115, 2018, doi: 10.1016/j.jrras.2017.10.009.

[9] J. H. Kim, "Three principles for radiation safety: Time, distance, and shielding," *Korean J. Pain*, vol. 31, no. 3, pp. 145–146, 2018, doi: 10.3344/kjp.2018.31.3.145.

[10] B. H. Lee *et al.*, "Analysis of Trends in Dose through Evaluation of Spatial Dose Rate and Surface Contamination in Radiation-Controlled Area and Personal Exposed Dose of Radiation Worker at the Korea Institute of Radiological and Medical Sciences (KIRAMS)," *Prog. Med. Phys.*, vol. 27, no. 3, p. 146, 2016, doi: 10.14316/pmp.2016.27.3.146.

[11] A. Zekioğlu and Ş. Parlar, "Investigation of awareness level concerning radiation safety among healthcare professionals who work in a radiation environment," *J. Radiat. Res. Appl. Sci.*, vol. 14, no. 1, pp. 1–8, 2021, doi: 10.1080/16878507.2020.1777657.

[12] S. Ozkan, G. Aba, and B. Tekinsoy, "The Importance of Radiation Safety in Terms

of Hospital Administration and Research on the Awareness Stage of Radiology Technicians," *J. Acad. Res. Med.*, vol. 6, no. 3, pp. 162–169, 2016, doi: 10.5152/jarem.2016.1056.

[13] K. Kamiya *et al.*, "Long-term effects of radiation exposure on health," *Lancet*, vol. 386, no. 9992, pp. 469–478, 2015, doi: 10.1016/S0140-6736(15)61167-9.

[14] M. Tubiana, "Dose-effect relationship and estimation of the carcinogenic effects of low doses of ionizing radiation: The joint report of the Académie des Sciences (Paris) and of the Académie Nationale de Médecine," *Int. J. Radiat. Oncol. Biol. Phys.*, vol. 63, no. 2, pp. 317–319, 2005, doi: 10.1016/j.ijrobp.2005.06.013.

[15] S. M. Fireman, "Background radiation.," *Oral Health*, vol. 72, no. 7, pp. 19–20, 1982, doi: 10.1017/upo9788175968158.012.

[16] M. Bagshaw, "Cosmic rays: Are air crew at risk?: Commentary," *Occup. Environ. Med.*, vol. 59, no. 7, pp. 432–433, 2002.

[17] S. Yasmin *et al.*, "The presence of radioactive materials in soil, sand and sediment samples of Potenga sea beach area, Chittagong, Bangladesh: Geological characteristics and environmental implication," *Results Phys.*, vol. 8, pp. 1268–1274, 2018, doi: 10.1016/j.rinp.2018.02.013.

[18] J. Reste, I. Pavlovska, Z. Martinsone, A. Romans, I. Martinsone, and I. Vanadzins, "Indoor Air Radon Concentration in Premises of Public Companies and Workplaces in Latvia," *Int. J. Environ. Res. Public Health*, vol. 19, no. 4, 2022, doi: 10.3390/ijerph19041993.

[19] G. Rajan, "Chapter 4," pp. 101–121.