value at about 0.64 toward the EOC. From the previous highlights, the mechanical SSC method has the potential for improving reactor conversion ratio and enhancing discharge burnup during one batch fuel cycle scheme.

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THE HISTORY ABOUT THE DISCOVERY OF RADIATION AND ITS IMPACT ON THE ENVIRONMENT AS A SUBJECT OF TECHNICAL SCIENCE

Abstract

The article examines the contribution of scientists to the development of nuclear physics. The scientific portals of outstanding physicists who have made a great contribution to the development of nuclear physics are presented. Such as Marie Curie, J. Thomson. The author examines what dangers await humanity during a nuclear catastrophe. The article substantiates the need to study the history of nuclear physics for a successful career of a modern engineer.

Wilhelm Roentgen was the first to discover radiation. He discovered it in the form of x-rays in 1985, using J. J. Thomson’s cathode ray tube (CRT) technology. The first medical x-ray image he took was of the hand of his wife, Anna Bertha Ludwig. Henri Becquerel decided to work further on Wilhelm Roentgen’s discoveries by experimenting with phosphorescent substances. He spread uranium salt on black paper with a photographic plate wrapped in it and

exposed it to sunlight for several hours. After developing the plate, he discovered a trace of a mark left on it and concluded that the penetrating rays emitted by the sunlight caused the trace. To validate his observations, he performed the experiment again, but due to poor weather conditions, he was unable to do it in the sun. He poured the uranyl potassium sulfate onto black paper with a photographic plate wrapped in it and placed it in a drawer for a few days. He then observed the plate and noticed the same trace as when it was placed in the sun, but this time it was more intense. He concluded that the traces were caused by the rays given off by the material (uranium salt), not by the sun. Marie Curie, a doctoral student of Henri Becquerel, and her husband, Pierre Curie, expanded on Becquerel's discoveries. They discovered polonium, radium, and thorium. Marie Curie coined the term "radioactivity" and won the Nobel Prize along with her husband and Becquerel [1].

Fig.1. a) Wilhelm Roentgen and the first x-ray image of his wife's hand [2]

Fig.1. b) Henri Becquerel, Marie and Pierre Curie [3].

Radiation is defined as energy that travels through space or matter in the form of energetic particles or electromagnetic waves. Ionizing and non-ionizing radiation are the two main types of radiation. Ionizing radiation is a type of radiation that has enough energy to knock an electron out of its atom. Beta particles, gamma rays, neutrons, alpha particles, and x-rays are examples of such radiation. Non-ionizing radiation, unlike ionizing radiation, travels through an atom and causes vibration but does not have enough energy to cause ionization. Examples include TV waves, visible light, radio waves, ultraviolet radiation, and microwaves [4]. The different forms of radiation have varying penetrating abilities, with alpha particles having the least by being stopped by a piece of paper and neutron having the most by being stopped by water. This is why water is used as a moderator in nuclear reactors to slow down fast neutrons. They also have varying frequencies and wavelengths, with ultraviolet radiation having the lowest frequency.

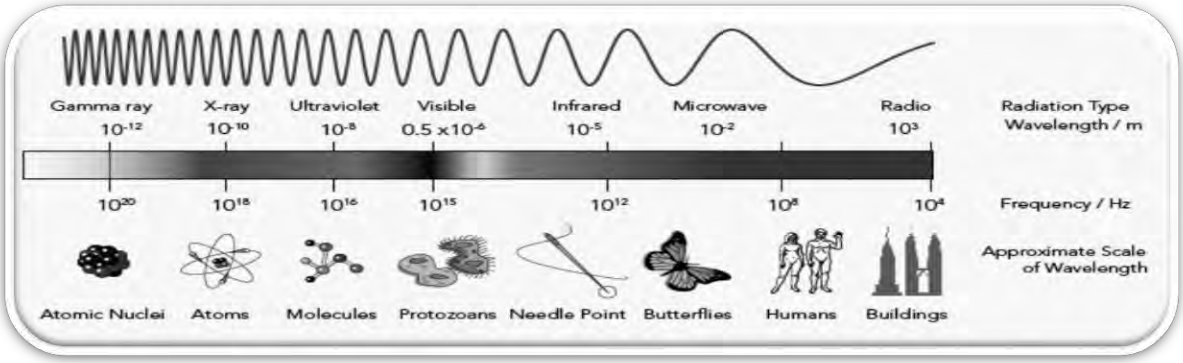

Fig.2. Types of radiation their wavelength and frequency [5].

There are two main sources of radiation: natural and artificial radiation. An artificial source contributes to about 20% of the sources of radiation in the environment. Natural sources of radiation are categorized into three sources: cosmic radiation, terrestrial radiation, and internal radiation. Cosmic radiation is the constant stream of highly charged particles that strike the Earth's surface from outer space. The atmosphere serves as a shield, so not all of the radiation from outer space gets to the earth's surface. This causes the radiation to increase with height. Radioactive materials found in the earth's rocks, minerals, and soil emit terrestrial radiation. Radon, thorium, radium, radon progeny, potassium, and uranium cause most of the terrestrial radiation. Radioactive elements in the environment can enter the human body through various ways of exposure, like inhalation and ingestion, and this is termed "internal radiation". The human body contains some radioactive isotopes such as carbon, potassium, and rubidium.

The artificial radiation sources come from consumer products and activities such as smoke detectors, tobacco products, building materials, and so on. Radiation is a very essential tool in the diagnosis and treatment of certain diseases, and this is the main source of artificial radiation. In addition, nuclear industries such as nuclear power plants, uranium mining, and fuel processing emit radiation into the environment. Also, occupations such as education, aviation, research, medicine, and so on that use radioactive materials in their activities also contribute to the radiation in the environment.

Radiation measurement is performed in order to determine the potential impact of radiation on the environment. When determining the amount of radiation in the environment, the activity or the rate of radioactive decay is measured. The traditional unit for activity is Curie (Ci) and the SI unit is Becquerel (Bq). Radiation absorbed dose (RAD) is the unit of measurement for expressing the amount of ionizing radiation absorbed by any medium.

Radiation enters the human body from various routes, known as "pathways". Radiation from outer space, for example, enters the earth's surface into the soil and water bodies through deposition. Humans inhale some, while others are passed on to plants as they grow in the soil. Humans and animals then consume the plants, absorbing the radiation. Humans consume the animals and their products as well, and the radiation is transferred to them. The radiation that enters into the water is passed to aquatic animals since they live in them. Humans become vulnerable when they drink from the water and consume aquatic animals [6].

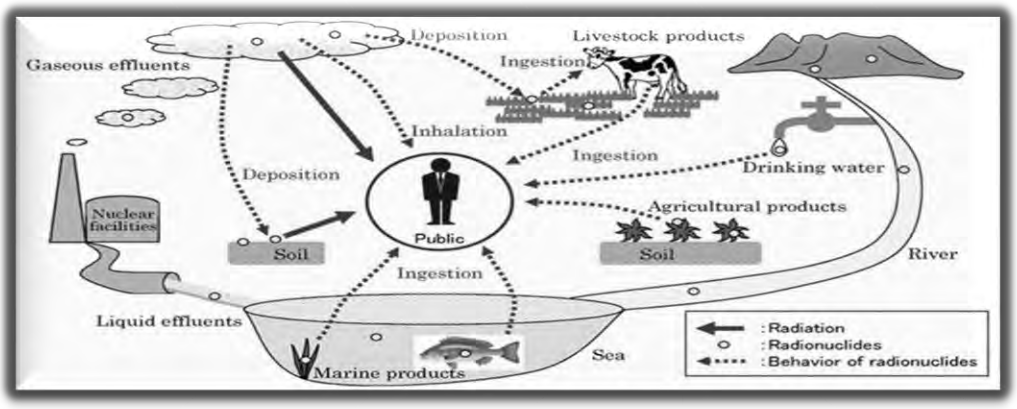

Fig.3. Pathway of radiation [7].

The pathway of radiation shows that radiation can be found all around us in the world, and it is therefore very important to know its impact on the environment. Both natural and artificial sources of radiation can affect humans, plants, and animals when they are overexposed to them. Nuclear accidents, such as those at Chernobyl and Fukushima, had serious environmental consequences. It caused environmental pollution in the atmosphere and mutations in plants and animals. Exposure to high-energy ionizing radiation, even at low doses, can cause damage to genetic materials in cells, resulting in cancer or diseases that can be transferred to the offspring of those exposed. Table 1 shows the effect of overexposure to radiation on some body parts of humans.

Table 1.

Effect of overexposure to radiation on some body part [8].

ORGAN	**EFFECT**
Brain	Fatigue, nausea
Hair	Loss of hair follicles and baldness
Intestine lining	Diarrhea and malnutrition
Bone marrow and white blood cells	Immune system failure
Uterus	Destruction of eggs
Body	DNA cleavage

Plants are also affected by radiation. The increase in Ultraviolet-B (UV-B) radiation enhances genetic mutation in plant growth, morphology, and physiology, but plants have repair mechanisms that deal with any stress shift. Different types of animals are affected differently by radiation. Vertebrates such as birds are not affected by radiation because they have protective covers such as fur, feathers, and pigmentation that protect them. Amphibians, unlike vertebrates, are affected by radiation because they are less protected. Mammals and aquatic animals have detrimental effects when overexposed to ionizing radiation [9].

a) *b)* *c)*

Fig.4. a) Mutant daisy from Fukushima accident [10] b) Animal after Chernobyl accident [11] c) Mutant fish [12].

The impact of radiation on the environment makes it very important to perform environmental radiation monitoring. Environmental radiation monitoring refers to the systematic collection and analyzing of particular media such as soil, water, and so on in the environment to monitor the level of radioactivity present in them. Alpha particles, gamma rays, beta particles, and neutrons are four types of radiation being monitored. Special devices have been designed for environmental radiation monitoring and are referred to as radiation detectors. Examples include scintillation detectors, semiconductor detectors, and gas-filled detectors.

To conclude, there is a need to perform environmental radiation monitoring to protect plants, animals, and people from the harmful effects of radiation. Knowledge expansion on radiation will help to fully restore, protect, and preserve our environment. Knowledge and understanding of the history of the development of science will undoubtedly contribute to the development of a successful career of a modern engineer [13].

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The article was written as part of National Research Tomsk Polytechnic University's Competitiveness Enhancement Program.