Token ID: Ain20220223013

Radioactive pollution

Executive summary:

Radioactive waste management can be defined as the cautious and safe approach to treating, storing, and disposing of discharged waste generated due to nuclear industry operations. The power plant industry, like any other industry, generates waste. Regardless of the fuel used to generate power, proper waste management should be ensured to protect human health and mitigate the effect on the environment. For generating nuclear power, the fuel required is very small and subsequently, the generated volume of waste is also comparatively small. However, most of the waste is radioactive in nature and requires effective management. To ensure this, isolation or reducing the concentration of any radioisotopes such that any rate or concentration of the isotopes returning to the ecosystem remains harmless. Unlike different sources of power generation, nuclear waste requires proper regulation to ensure zero pollution. A permanent disposal method has been deemed suitable for low to moderate level waste. For high level waste, facilities are under implementation and construction.

Table of Contents

The problem: 4

Solution: 5

Ion exchange Method 5

Synthetic rock or synroc 5

Nuclear transmutation 6

The best solution: 6

Conclusion: 7

References: 8

The problem:

Radioactive pollution arises due to the presence of radioactive elements in the environment or the biosphere. The source of radioactive waste exists mainly in two forms. The first from the left-over fuels used in nuclear power plants. The other comes from organizations which reprocess and recycle the used fuel from the power plants to generate other nuclear products. Most of this waste remains highly hazardous for thousands of years [1].

The issue magnifies when the presence is due to accidents or it possesses environmental threats due to decaying. The destructive factors of the waste lie within the emissions or decaying into alpha or beta particles or gamma rays and neurons into the biosphere. Due to unstable characteristics of these particles, they are highly potent and can alter or even kill plant, animal and human lives. The effects of radiation on genetics are highly adverse. The mutation caused in the genes depends upon the extent of exposure to radiation in the biosphere, food and water. Once the radiation enters the body, it remains active and makes one highly prone to cancer which poses a great threat in relation to global health. Radioactive pollution also has severe effects in the alteration of biological cells. Radiation causes distortion in cells resulting in permanent damage to various organs. In cases of severe exposure, the entire organ system may fail leading to permanent illness and cause death. Radiation also poses serious threats on wildlife [2]. Higher levels of organisms are more prone compared to lower-level organisms. Cattles when grazes on contaminated land caused by pollution, certain radiation gets accumulated in their metabolic cycles causing genetic changes. This affects future generations of such animal families and pose severe risk of health concerns. Radioactive pollution in the form of ultraviolet rays is a great threat to plant life. When radiation affects the chromosomes, the reproduction cycle is hampered. This results in the modified shape and size [3]. The release of nuclear waste in the form of radioisotopes for years, although in permissible amounts, has affected marine life. Radionuclides of several elements have been detected in the tissues and bones of fishes. The shells of several marine lives have been contaminated with radionuclides. The effects are also visible in soils. The presence of more than one type of radioactive substance in the soil causes them to react together with various nutrients in the soil leading to the destruction of such nutrients. This makes the soil highly infertile and toxic. Harvesting crops in such soil is contaminated with radiation and becomes unfit for consumption. Also, the plants growing in such soil have mutated genes and the radiation gets transferred to the animals consuming such plants. Carnivores that consume these herbivores are subsequently affected by the radiation thus distorting the entire food chain.

Solution:

The present situation calls for immediate reviewing and implementing critical steps towards developing a constant effective approach for dealing with future nuclear waste and effective strategies for long-term storage and dumping used nuclear fuels and high radioactive wastes. The following three methods have been deemed best suitable for this purpose:

Ion exchange Method

The ion exchange method is considered one of the most effective methods to dispose of nuclear waste in the form of liquid. Various forms of this method are currently being researched actively to improve efficiency and mitigate the harmful consequences. For high-level liquid radioactive wastes, these are firsts separately stored in water bodies for a natural reduction in radioactivity by decaying. These are then processed through ionic exchange-based treatments where anions and cations are replaced between an insoluble solid matrix comprising ionizable polar groups and a liquid solution. Ionic resins are used in exchanger instruments where the radioactive nuclides are effectively filtered using inorganic ion exchangers, organic ion exchangers, or synthetic ion exchangers. This process can be carried out in parts or a continuous manner. When the salt content of suspended solids, organic pollutants, and radionuclide in the waste is high, it is required to be pre-treated before the exchange process can be carried out [4].

Synthetic rock or synroc

Second comes the ***synthetic rock or synroc*** process. The process is used to stabilize high-level nuclear waste in the form of dilute solid solutions. Synroc comprises primarily three titanate minerals namely hollandite, zirconolite, and perovskite. Along with these, rutile and some amount of metal alloy are used as well. These substances are combined in a slurry and a portion of high nuclear waste is added along. The mixture is then dried and reduced to 750 degrees Celsius. Afterward, using a process known as Isostatic Pressing, the powder is compressed within a stainless-steel vessel at operating temperatures between 0050-1200 degrees Celsius. This process has been proved to be very effective against hydrothermal leaching and hence is considered superior to other ceramic waste forms. Certain inherent properties of sync give it an upper hand over alternate methods. It is economically cheaper and its lucid operation in the hot-pressing process makes it suitable for use in remote operations in hot cells. This coupled with the extraordinary resistive capacity exhibited by synroc along with its ability to separate high-level wastes from the biosphere in fast leaching tests has provided researchers with plenty of confidence regarding the future sustainability of the method [5].

Nuclear transmutation

The final process considered is known as **a *nuclear transmutation***. In this process, the large amount of nuclear waste that has been accumulating in temporary storage sites would be bombarded using nuclear means. This would convert the highly radioactive substances into relatively safer forms in 300 years. To carry out the procedure, a particle accelerator or a reactor, or even both bombard the waste using neutrinos. This enables the waste atoms to undergo the process of nuclear fission and convert into lighter and safer isotopes which can decay relatively faster. The process involves the separation of components from the waste at various stages which will enable the extraction of some valuable reactor fuel and allow the more harmful components for further processing, separating the relatively less harmful components for permanent burial. Several theories suggest that transmutation will greatly help in reducing the time for which the waste remains hazardous. Wastes that could take up to 10 million years to become lighter will be diluted in about 300 years using this method. This would facilitate the development of storage sites that are required to store contents for a few centuries rather than millions of years. As this process is involved in recycling reactor fuel, it will also have a positive impact on the operating cost to produce power [6].

The best solution:

From the above discussions and arguments concerning the three prospects that could highly facilitate safe nuclear waste removal, nuclear transmutation provides researchers with the highest hope. This method is considered to be the most pragmatic and relatively easy to implement due to its lower requirements to operate. It only requires a particle accelerator or a reactor to carry out the operation which is effective in terms of cost and operational complexities [7]. Several studies are also considering the possibility of designing a reactor that will simultaneously generate power while processing the waste. This can prove to be highly efficient.

Other models also suggest that the process could be used to produce plutonium fuel from the waste that can be used in power plants and other nuclear sectors. With the implementation of proper techniques and methods, the fuel needed for the reactors required for the process can be used to last at least 100 times that of conventional reactors [8].

Conclusion:

There is no shadow over the preference for clean sources of energy to protect and safeguard every living organism on the planet. The present scenario concerning the pollution and effects caused by millions of tonnes of nuclear waste is complicated. The huge nuclear waste poses high threats to all forms of life, especially in the case of an accident. As a result, scientists and researchers around the world are working to create safe and sustainable models and theories that will ensure safer and convenient disposal of waste with minimal risks. Governments and organizations are constantly developing superior ways to ensure safe transportation, storage, and disposal of the radioactive waste that has been accumulating over years.

References:

[1]M. Hietala and R. Geysmans, "Social sciences and radioactive waste management: acceptance, acceptability, and a persisting socio-technical divide", Journal of Risk Research, pp. 1-16, 2020. Available: 10.1080/13669877.2020.1864010.

[2]D. Deng, L. Zhang, M. Dong, R. Samuel, A. Ofori-Boadu and M. Lamssali, "Radioactive waste: A review", Water Environment Research, vol. 92, no. 10, pp. 1818-1825, 2020. Available: 10.1002/wer.1442.

[3]A. Hasegawa et al., "Health effects of radiation and other health problems in the aftermath of nuclear accidents, with an emphasis on Fukushima", The Lancet, vol. 386, no. 9992, pp. 479-488, 2015. Available: 10.1016/s0140-6736(15)61106-0.

[4]J. Neeway et al., "Ion-Exchange Interdiffusion Model with Potential Application to Long-Term Nuclear Waste Glass Performance", The Journal of Physical Chemistry C, vol. 120, no. 17, pp. 9374-9384, 2016. Available: 10.1021/acs.jpcc.6b03681.

[5]A. Orlova and M. Ojovan, "Ceramic Mineral Waste-Forms for Nuclear Waste Immobilization", Materials, vol. 12, no. 16, p. 2638, 2019. Available: 10.3390/ma12162638.

[6]A. Terashima and M. Ozawa, "Evaluation of the specific radioactivity of 40 elements created by nuclear transmutation of fission products", Progress in Nuclear Energy, vol. 93, pp. 177-185, 2016. Available: 10.1016/j.pnucene.2016.08.015.

[7]M. Fukuhara, A. Yoshino and N. Fujima, "Earth factories: Creation of the elements from nuclear transmutation in Earth's lower mantle", AIP Advances, vol. 11, no. 10, p. 105113, 2021. Available: 10.1063/5.0061584.

[8]M. Ramana, "An Enduring Problem: Radioactive Waste From Nuclear Energy [Point of View]", Proceedings of the IEEE, vol. 105, no. 3, pp. 415-418, 2017. Available: 10.1109/jproc.2017.2661518.