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ENVIRONMENTAL ISSUES OF RADIOACTIVE WASTE DISPOSAL

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Abstract: This article examines the environmental challenges of ensuring the safe storage, transportation, and disposal of radioactive waste today. The problem of nuclear waste disposal and reforming comprehensive radioactive waste disposal measures is one of the most dangerous in the modern world. The disposal and disposal of radioactive waste from nuclear power plants is becoming particularly pressing today, requiring the selection of optimal disposal sites and methods. Methods for the disposal of low-, intermediate-, and high-level waste accumulated at nuclear power plants are also discussed.

Keywords: Environmental disaster, radioactive waste, principles of dissolution and concentration, London Convention, spent nuclear fuel, waste packaging, concrete bunkers, buffer zones, disposal methods, vitrification procedure.

INTRODUCTION

Humans have always used the environment primarily as a source of resources, but for a very long time, their activities had no noticeable impact on the biosphere. Only in the late 19th century did changes in the biosphere due to economic activity attract the attention of scientists. In the first half of the 20th century, these changes intensified and are now overwhelming human civilization. Striving to improve their living conditions, humans constantly increase the rate of material production, without regard for the consequences. With this approach, most of the resources taken from nature are returned to it as waste, often toxic or unsuitable for disposal. This poses a threat to both the biosphere and humans themselves.

In the modern world, the problem of radioactive waste disposal remains pressing and requires the development of new solutions. Radioactive waste contains radioactive isotopes, which pose a serious threat to human health and the environment due to their ability to emit ionizing radiation. The challenge of radioactive waste disposal lies not only in ensuring the safety of its storage and transportation, but also in choosing the optimal disposal location and method, as well as government regulation.

LITERARY RESEARCH

It should be noted that one of the dangers threatening modern civilization and humanity is environmental crises with their many components, including the environmental problems of radioactive waste disposal, which accompany environmental pollution. At the current stage of human development, humanity is faced with perhaps the most pressing issue: how to preserve nature and civilization, since no one knows when and in what form a particular disaster might occur.

Humans' uncontrolled encroachment on nature and its callous exploitation over centuries, particularly since the onset of the Industrial Revolution, have led to a situation where the state of the environment has begun to threaten the quality of life and the very existence of human society. Over the past two decades, a huge number of localized environmental disasters have negatively impacted the environment. Humans return the benefits they receive from nature to it

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in a depleted form, resulting in the pollution of the planet. And this process is accelerating every year. For several generations, the alarm has been raised, raising awareness of these issues. According to the website [1], radioactive waste is generated at all stages of the nuclear fuel cycle: during uranium ore mining and processing, nuclear fuel production and use, reprocessing of irradiated fuel, and the decommissioning of nuclear facilities. According to the International Atomic Energy Agency, 442 nuclear reactors currently operate in 31 countries, generating electricity. Currently, no country has moved to the use of technologies that can completely solve the problem of spent nuclear fuel management.

The source [2] notes that there are two main methods for reducing the radioactivity of nuclear waste: the dilution principle and the concentration principle. The dilution principle involves accelerating the decomposition of radioactive substances and the discharge of waste into the atmosphere and water bodies in order to prevent a detrimental effect on the protected resource. With the onset of widespread development of nuclear energy, many countries began dumping low- and intermediate-level radioactive waste into the open sea. This practice was officially banned in 1983 by the London Convention for the Protection of the Sea due to growing concerns about this disposal method. Prior to 1983, therefore, the disposal of high-level nuclear waste was apparently not practiced. The dilution principle is still partially used today in the handling of gaseous and aerosol radioactive waste. Such waste is subject to aging or purification in filters in order to reduce its activity to levels regulated by permissible release, after which it can be released into the atmosphere. According to popular belief, such contamination does not cause human illness.

L.I. Markitanov's article [3] analyzes the main problems arising in the neutralization, recycling, and disposal of radioactive waste (RW). The problem of recycling and disposal of RW from nuclear power plants (NPPs) is particularly acute at present, when operating conditions require dismantling the majority of NPPs worldwide (more than 65 NPP reactors and 260 reactors used for scientific purposes). Every sixth reactor operates on Russian fuel, meaning that spent nuclear fuel (SNF) from these NPPs is returned to the Russian Federation. More than 436 nuclear power units are in operation worldwide. NPPs generate more than 17% of all electricity. The total amount of spent nuclear fuel accumulated worldwide exceeds 200,000 tons. Designing, constructing, and operating a radiochemical facility for the reprocessing and storage of spent nuclear fuel and radioactive waste is only economically feasible for a country with a developed, independent nuclear energy industry, the necessary technologies, and highly qualified personnel. Currently, radiochemical plants operate in Russia, France, and the United Kingdom. The United States is pursuing a deferred decision, preferring to preserve spent nuclear fuel in special storage facilities for future reprocessing or final disposal. Nuclear fuel supplied by the United States to other countries is not returned to the United States for reprocessing, therefore, the problem of its disposal falls entirely on importing countries. Methods for the disposal and elimination of radioactive waste implemented in the Russian nuclear energy sector are examined. Theoretical and practical solutions for radioactive waste reprocessing are described. Liquid and solid radioactive waste are classified. Examples of some radioactive waste storage facilities and processing plants are given.

According to a source [4], seven years after the 2011 accident at the Fukushima Daiichi Nuclear Power Plant, a decision regarding the disposal of radioactive waste has still not been made. More than 203,000 tons of such waste (Fig. 1) are temporarily stored at wastewater treatment facilities and on agricultural land in 11 prefectures. The Ministry of the Environment plans to build three disposal facilities – one each in Tochigi, Chiba, and Miyagi prefectures. However,

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efforts to resolve the disposal issue have been unsuccessful, as local residents oppose the construction plans.

Figure 1. Illustration of the decontamination process of a community in Fukushima Prefecture (Japan Daily Press News, March 12, 2018).

As noted in source [5], the type of radioactive waste repository is determined by the geological conditions prevailing in a given country, the specific requirements for the disposal facility, and general regulatory provisions. All of these factors are directly related to the design of the repository, the primary purpose of which is to limit the release of radioactive contaminants or radionuclides into the biosphere, minimize the exposure of workers and the public, and minimize the need for maintenance of the repository after its closure. These goals can be achieved through such technical measures—or a combination of them—as waste packaging in containers, repository engineering, and the use of site features. Some observed trends in repository design are related to technological advances in waste disposal and public concern about safety issues. The main general trend is toward greater reliance on a system of multiple engineered containment measures to ensure waste containment. Such a system includes concrete bins or chambers, backfill materials, chemical sealants, ventilation to remove gases, water drainage, and the creation of buffer zones on the ground surface.
Source [6] lists (Table 1) the main problems associated with radioactive waste disposal.
Table 1

Problem	Description

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1. Longevity of Radiation	Some radioactive materials, such as cesium-137 and strontium-90, have long half-lives (over 30 years). Iodine-129 has the longest half-life – 15.7 million years.
2. Large Quantities of Accumulated Radioactive Waste	This raises serious concerns due to the potential radiation hazard. Typically, nothing can be done with this waste.
3. Safety and Monitoring	Since radiation is extremely dangerous to humans, it requires strict control. This necessitates ensuring waste safety over the long term, requiring the development of monitoring and control systems for waste condition. Because some waste cannot be recycled, it is simply buried in repositories for an indefinite number of years. This area requires constant monitoring and secrecy.
4. Public Opinion	: The disposal of radioactive waste often provokes various protests from environmental activists, especially in the current paradigm. People fear potential risks to their health and the environment.
5. Risk of Leakage and Contamination	Violating radioactive waste storage regulations can result in contamination of soil, water, and air, which is extremely dangerous.

Methodology

Nuclear waste poses a serious environmental problem due to its high radioactivity and long-term environmental and health consequences, requiring strict controls and safe disposal methods.

The issue of public radiation safety, nuclear waste disposal, and reforming comprehensive radioactive waste disposal measures is one of the most pressing in the modern world. The main challenges of radioactive waste disposal are its long half-life, large volume, high risk to life and the environment, enormous cost, complex regulations, and the lack of generally accepted safe technologies. This waste can contaminate water, soil, and the food chain, causing mutations, poisoning, and death, and its disposal requires the construction of expensive and durable repositories.

The price of cheap energy and cutting-edge medical and other technologies is the steady increase in the amount of radioactive waste, which poses a huge danger. This type of hazardous waste is found not only at nuclear power plants and in the aftermath of man-made disasters. Many types of industrial, scientific, and medical equipment use radioactive elements of one kind or another. The proper disposal of such spent materials is the responsibility of the facility's management. The most practical solution is to enter into an ongoing maintenance contract with a licensed company.

For substances with a relatively short half-life, the simplest disposal method is temporary storage in sealed containers at special landfills. Over time, when the hazardous substances have completely decayed, the remaining materials will become ordinary household waste and can be disposed of using conventional methods. This option is typically used with most medical and technical radiation sources: these devices use short-lived isotopes with half-lives of no more than a few years. Metal drums, for example, can be used as containers for such waste. To

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prevent medium- and low-active waste from leaving the container, it is filled with bitumen or cement.

A limited number of specialized facilities handle the high-level waste generated at nuclear power plants. These facilities utilize specialized chemical processing technologies to extract most of the radioactive material and recycle it for reuse. This significantly reduces the volume of radioactive waste, but complete decontamination is still technically impossible. Therefore, the next stage of disposal is preparation for very long-term (practically indefinite) storage.

Vitrification helps prevent the release of highly radioactive materials into the environment. This involves mixing hazardous radioactive waste with liquid glass melted in an induction furnace. The resulting homogeneous mass is poured into thick-walled containers made of alloy steel. In its solidified form, it is extremely resistant to chemicals and water—in this form, the radioactive materials are considered ready for disposal in underground storage facilities.

Conclusions

Based on the above, it can be concluded that the problem of radioactive waste disposal is the most pressing issue in the modern world. It's no secret that hundreds of thousands of tons of various waste are sent to landfills every year in countries around the world. This waste pollutes the soil, water, and air, causing irreparable harm to the ecosystem. All countries around the world are considering ways to improve radioactive waste disposal. While some progress has been made, an ideal form of radioactive waste disposal has yet to be found.

It should be noted that the current state of radioactive waste disposal negatively impacts the environment and causes enormous harm to the human population and other living organisms. As we can see, the negative consequences of industrialization in all regions and countries of the world have forced humanity to take urgent measures to address the problem of radioactive waste disposal.

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