

THE IMPACT OF POTENTIAL NUCLEAR RADIOLOGICAL ACCIDENTS AT NUCLEAR POWER PLANTS OF NEIGHBORING COUNTRIES ON THE REGION'S RADIOECOLOGY

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Abstract: Nuclear radiological incidents can have serious, long-lasting effects on the environment. The potential for such accidents to affect the environment is related to the leakage of radioactive materials into the atmosphere, soil, and water resources. Radioactive substances released into the environment as a result of nuclear radiation can accumulate in the soil. Pollution like this can lower soil fertility and damage vegetation. In the long term, this soil contamination can have a negative impact on agriculture and ecosystems. Nuclear radiological incidents can result in the leakage of radioactive chemicals into water supplies. This can lead to the contamination of lakes, rivers, and groundwater sources. The availability of irrigation water as well as supplies of drinking water can be negatively impacted by water source contamination. Both plant and animal life may be impacted by radioactive pollution. This can reduce the population of species that cannot withstand environmental radiation and cause an imbalance in ecosystems. Due to the lengthy half-life of radioactive materials, environmental contamination can persist for several years or even decades. The region may have long-term repercussions from this. People in close proximity to a nuclear radiological accident may be exposed to radiation. It can result in cancer, genetic mutations, and other health problems. The evacuation or migration of people in the vicinity may be required in the wake of nuclear radiological accidents. Communities may become dispersed and disintegrated as a result.

For these reasons, it is crucial to ensure the safe operation of nuclear facilities, avoid radiation leaks, and minimize environmental radiation contamination. Furthermore, essential to environmental protection is the development and implementation of emergency plans and nuclear accident response strategies.

Keywords: nuclear accident, radioecology, nuclear power plants.

1. Introduction

In many places of the world, energy security and climate change are grave concerns and are becoming more so. These two problems are related to one another, and using nuclear energy can help to resolve them both. Numerous problems that contribute to global warming and a decline in framework resistance have an impact on climate change. The combustion of fossil fuels increases carbon emissions, which in turn causes greenhouse gas emissions and climate change. The ability to generate energy with minimal carbon emissions through nuclear power helps mitigate climate change. Nuclear energy enables highly efficient energy generation and produces relatively little nuclear waste. As a result, the carbon emissions from the combustion of fossil fuels are extremely low. Furthermore, nuclear energy offers a warm and steady energy source. The information presented here explains how nuclear power can be used to address energy security and

climate change-related challenges. On the other hand, nuclear power itself poses additional risks and necessitates cautious and corrective safety precautions.

Globally, nuclear power plants are significant establishments utilized for the generation of energy. Possible nuclear radiological accidents at these installations could have a catastrophic impact on the local ecology and public health. The consequences of nuclear radiological accidents can vary depending on the scale of the incident, the ways in which they spread to the environment, and the rate of radiation. Potential consequences of nuclear radiological incidents on the local radioecology include:

Radiation release: Nuclear reactors run the risk of releasing radioactive elements into the atmosphere or bodies of water during a nuclear radiological catastrophe. Ecosystems and living things in the environment may be negatively impacted by the radiation emitted by these radioactive materials.

Health risks: Human health may be seriously threatened by nuclear radiation. Genetic mutations, cancer, and other health problems can result from radiation exposure. Individuals and living things in the vicinity may be exposed to this harmful radiation.

Environmental Effects: Wildlife and ecosystems in the area may be impacted by the environmental effects of nuclear radiological incidents. Vegetation and groundwater supplies may be harmed by radioactive contaminants that seep into soil and water sources.

Agriculture and Food Production: Livestock and agricultural goods may also be impacted in areas where nuclear radiological accidents occur. Radioactive contamination finds its way into the food chain, resulting in radiation exposure to humans through the food consumed.

Long-term effects: Nuclear radiation can have long-lasting impacts. Environmental contamination can persist for years or even decades due to the lengthy half-life of radioactive substances.

Thus, ensuring the prevention of nuclear radiological incidents and implementing significant safety measures for nuclear installations are crucial. In addition, contingency plans and response strategies should be established to minimize the environmental effects of nuclear radiation and protect the region. The environment and public health can be safeguarded during nuclear power plant operations by strictly adhering to national and international nuclear safety regulations.

To operate nuclear facilities and combat radiation, radiation control and leak prevention are crucial concerns. The actions listed below can be implemented to counteract radiation:

Nuclear Facility Safety: Radiation leakage must be minimized through the safe operation and maintenance of nuclear facilities. Facilities require routine renovations and maintenance.

Radiation Control: It is imperative to continuously monitor and control the levels of radiation within the facility. Radiation levels within the facility must be monitored using radiation measuring devices.

Preparedness for nuclear accidents: Contingency plans should be developed in the event of nuclear accidents. These strategies, which also include actions to stop the spread of radiation, are intended to safeguard neighboring residents and facility employees.

Radioactive Waste Management: It is necessary to safely store and dispose of radioactive waste produced in nuclear plants. It should not be possible for these wastes to leak uncontrollably into the environment.

Monitoring of radiation leaks: Radioactive leaks should be identified by establishing environmental radiation monitoring systems. These systems monitor the amount of radiation emitted into the environment and the modes of emission.

Training People: It's critical to raise awareness of radiation hazards among the local populace near the site. It assists people in adopting preventative measures and, if needed, adhering

to evacuation plans.

National and International Cooperation: Regarding nuclear safety, both national and international collaboration is crucial. In times of crisis, exchanging knowledge and expertise might help facilitate a more efficient response.

Prevention and management of radiation leakage are the primary goals of the safe operation of nuclear facilities and radiation control. These measures help to lessen the negative effects of radiation on human health and the environment.

Since accidents at nuclear facilities can have catastrophic repercussions, nuclear facility safety is extremely important. Several precautions and measures must be taken to ensure the safety of nuclear facilities. The following are the primary concerns about nuclear facility safety:

- ✓ The design and construction of nuclear facilities are of great importance to prevent radiation leakage and ensure the safe operation of the facility. Safety regulations must be followed in the construction and design of facilities.
- ✓ Regular maintenance and inspections guarantee the safety of nuclear installations. The operational conditions of the facilities must be constantly monitored and controlled.
- ✓ Facility staff must be trained in nuclear safety issues. They must be trained in topics such as radiation risks, emergency procedures, and safety protocols.
- ✓ Radiation levels within the facility must be constantly monitored and controlled. A prompt reaction to radiation leakage depends on early detection.
- ✓ Contingency plans for potential accidents must be established for nuclear installations. Actions to safeguard local people and facility employees are included in these plans.
- ✓ Safe storage and disposal of radioactive waste is part of the safety of nuclear plants.
- ✓ Independent inspections of nuclear plants are required regularly. This ensures the safe operation of facilities.
- ✓ When it comes to nuclear safety, national and international cooperation is crucial. Sharing knowledge and expertise can improve nuclear safety.

The safety of nuclear facilities is a vital issue in terms of preventing radiation leakage and minimizing the effects of nuclear accidents. Therefore, the safe operation of facilities and compliance with safety standards are of great importance.

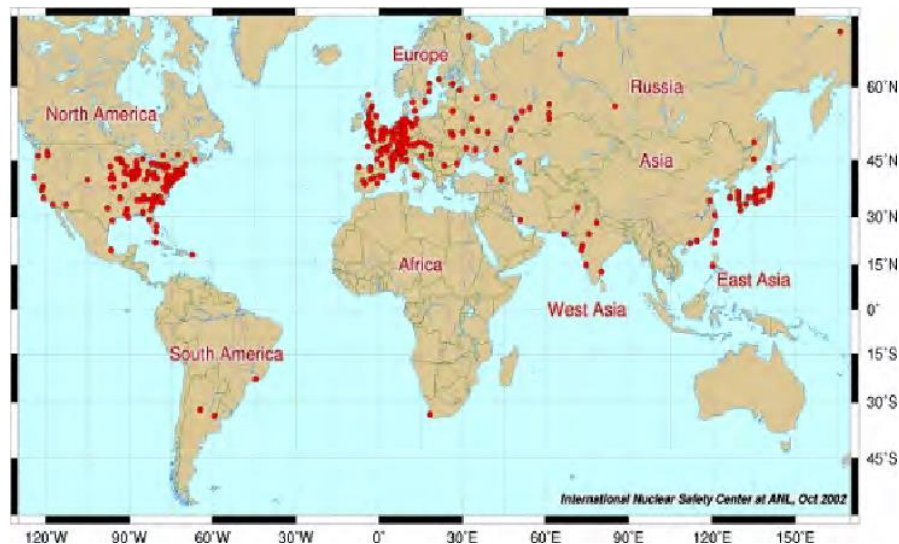


Fig. 1. A map showing the locations of operating nuclear power plants by continent

Nuclear radiological accidents are serious events that are theoretically possible in nuclear power plants (NPP). Human error, technological malfunctions, natural calamities, or malevolent activities are frequently the causes of these kinds of incidents. Below are some examples of nuclear radiological accidents at nuclear power plants and their potential consequences:

1. Accident at the Chernobyl Nuclear Power Plant (Chernobyl, Ukraine, 1986):

The Chernobyl Nuclear Power Plant accident was a serious nuclear accident that occurred on April 26, 1986, near Pripyat, Ukraine. This incident, which has had a significant negative influence on the environment and human health, is regarded as the most catastrophic nuclear disaster in world history. The main features of the Chernobyl Nuclear Power Plant accident are:

Cause of the accident: The primary cause of the accident was the overheating and explosion of the nuclear reactor during an uncontrolled test at reactor number 4. As a result of the explosion, radioactive substances were released into the atmosphere.

Radiation leakage: A significant quantity of radioactive material was released into the environment as a result of the explosion and fire. This led to widespread radioactive contamination.

Evacuation and affected areas: Pripyat and its environs were evacuated as a result of the accident's effects. The evacuation zone is known as the "Chernobyl Exclusion Zone" and still contains deadly levels of radiation.

Effects on Human Health: Many people were exposed to radiation as a result of the accident. People with cancer, genetic mutations, and other health problems are becoming more prevalent.

Environmental impacts: The accident had a significant negative environmental impact. Vegetation, forests, and water resources were affected. Animals and plants were adversely affected by radiation as well.

The disaster at the Chernobyl Nuclear Power Plant was a significant turning point in both the safety of nuclear plants and the usage of nuclear energy. Following the catastrophe, nuclear safety standards were significantly revised, and the safety of nuclear facilities around the world was taken more seriously. Concurrently, the accident's effects on human health and the environment sparked debate over nuclear energy use and raised awareness of renewable energy sources.

2. Accident at Fukushima Daiichi Nuclear Power Plant (Fukushima, Japan, 2011):

The catastrophe that happened at the Fukushima Daiichi Nuclear Power Plant on March 11, 2011, as a result of the strong earthquake and the subsequent tsunami that hit Japan, was recorded in history as a serious nuclear incident. Around the world, this accident sparked a lot of curiosity and worry.

The main cause of the accident was the earthquake and subsequent tsunami in the area where the power station is located. The plant's resistance to power outages was decreased by these natural calamities, which also disrupted cooling systems. Three nuclear reactors experienced overheating as a result of the failure of their cooling systems. The nuclear fuel melted due to the temperature rise.

The following are the principal fallout from the Fukushima Daiichi Nuclear Power Plant accident:

Radiation leakage: As a result of the explosion and meltdown of the reactors, a large amount of radioactive material was released into the atmosphere, the sea, and the environment. This led to environmental pollution and the spread of radiation.

Evacuation: About 160,000 people were evacuated, and many people fled their homes due to the impact of the accident.

Restrictions on Agricultural and Food Products: Radiation contamination places significant restrictions on agricultural and marine products.

Effects on Human Health: Individuals exposed to radiation following the catastrophe saw an increase in health issues, including cancer.

Plant Safety: The incident raised concerns about the safety of nuclear power plants and led to new regulations to make such facilities safer.

The Fukushima Daiichi Nuclear Power Plant tragedy brought nuclear safety concerns to light and prompted evaluations of the safety of nuclear installations worldwide. This accident showed that nuclear power plants should be better prepared for earthquakes, tsunamis, and other natural disasters.

3. *Three Mile Island NPP Accident (Pennsylvania, USA, 1979):*

On March 28, 1979, in Pennsylvania, USA, a nuclear catastrophe known as the Three Mile Island (TMI) Nuclear Power Plant accident was recorded in history. This event is significant because it has an impact on nuclear power plant safety concerns as well as public opinion of nuclear power. The main features of the Three Mile Island Nuclear Power Plant accident are:

The beginning of the accident: The accident occurred as a result of a series of errors and confusion in the cooling systems of the second unit of the power plant. These errors caused the reactor's nuclear fuel to overheat and partially melt.

Meltdown and Radiation Leakage: Part of the reactor melted down, and radiation leakage started. Nevertheless, the leak did not escape into the atmosphere; instead, it stayed inside the reactor building.

Evacuation: About 140,000 people have been evacuated or removed from the area to minimize potential hazards.

Effects on Human Health: Fortunately, no serious unintentional radiation exposures or fatalities have occurred. Nonetheless, many people were impacted by the accident's psychological and physical ramifications.

Shutting down the Power Station: After the accident, the TMI-2 reactor was completely shut down and dismantled. The reactor, named TMI-1, continued to operate safely.

More safety precautions at nuclear sites and more stringent inspections of the nuclear sector followed the Three Mile Island Nuclear Power Plant accident. Furthermore, it has had a detrimental impact on public support for and confidence in nuclear power as well as the development and construction of nuclear power projects. This incident was a turning point in the need to improve public understanding of nuclear energy and make it safer.

4. *Chalk River Nuclear Laboratory Accident (Ontario, Canada, 1952):*

The Chalk River Nuclear Laboratory Accident went down in history as a nuclear accident that occurred on December 12, 1952, in Ontario, Canada. This accident happened as a result of a nuclear reactor's uranium rods melting and causing a radiation leak. Information on the Chalk River Nuclear Laboratory Accident:

Cause of the accident: An experiment was being carried out at the NRX (Nuclear Research Experimental) nuclear reactor at the Chalk River Nuclear Laboratory. During this experiment, it was being worked on uranium rods, and there was a loss of thermal control that caused one of the rods to melt.

Radiation leakage: Radiation leaked out as the uranium rods melted due to a lack of thermal control. Radiation contaminated the reactor coolant. Because of this leak, nearby residents and lab personnel were exposed to dangerous radiation levels.

Environmental impacts: The Chalk River catastrophe affected water sources. The river waters were polluted, and aquatic life in the region suffered. Furthermore, workers' and residents' health was seriously at risk from radiation leaks.

Cleaning and Repair: Following the accident, efforts were made to clean up the contaminated areas, and the laboratory was repaired. However, the fight against radiation

contamination and the cleanup process required a long-term effort.

The Chalk River Nuclear Laboratory Accident has re-emphasized the importance of nuclear safety measures and the precautions that must be taken during reactor operation. Nuclear plant safety and bolstering safeguards against radiation leaks gained importance following the accident. These accidents led to the development and improvement of safety standards in the field of nuclear energy.

5. *Goiania Radioactive Contamination Accident (Goiania, Brazil, 1987):*

The Goiânia Radioactive Contamination Accident was a significant radioactive contamination incident that occurred on September 13, 1987, in Goiânia, Brazil. This accident occurred as a result of the theft of radiotherapy equipment by scrap dealers and caused massive radiation pollution. Information on the Goiânia Radioactive Contamination Accident:

Cause of the accident: The accident was primarily caused by scrap dealers stealing the outdated radiotherapy apparatus. Cesium-137, which is used to disinfect bodies for radiation therapy, was present in this gadget.

Radiation leakage: The opening of a Cesium-137 capsule and subsequent radiation release were caused by the theft of an abandoned radiotherapy apparatus. The device's stolen parts and environmental contamination were the main ways in which this radioactive contamination spread.

Effects on Human Health: Numerous individuals were exposed to radiation in a significant way as a result of the radiation spill. Many people have suffered from radiation poisoning and health problems caused by this radiation. In addition, people exposed to radiation may have long-term health effects.

Environmental impacts: Contamination has a detrimental effect on the environment as well. Decontamination and cleanup operations were necessary since the surrounding environment was radioactively polluted.

Evacuation: It was necessary to evacuate and remove locals from the affected areas following the catastrophe.

The Goiânia Radioactive Contamination Accident is a tragic event that demonstrates the serious consequences of radiation contamination. The significance of using, storing, and transporting radioactive material securely is underscored by such incidents. Additionally, it highlights the necessity of regular inspections, safety precautions against radiation sources, and the safe disposal of radioactive material and debris.

Metsamor Nuclear Power Plant — a nuclear power plant located in Metsamor, Armenia. During the Soviet Union, this power plant was constructed and put to use. It has two nuclear reactors, both VVER-440 models.

The Metsamor Nuclear Power Plant began operations in the 1970s with the Metsamor-1 reactor, which was its first reactor. Metsamor-2, a second reactor, was constructed later, in the 1980s. The worldwide community, however, expressed concerns about the safety and risk of earthquakes associated with this power plant.

Metsamor-1 was closed in 1988 because of the possibility of earthquakes, while Metsamor-2 was closed in 1989 for similar reasons. To meet Armenia's energy needs, Metsamor-2 was later partially restarted, but the international community expressed grave concerns over this choice. Later, in 2004, it was shut down entirely.

Due to safety and environmental concerns, the Metsamor Nuclear Power Plant has drawn attention from around the world, and alternative energy sources have been investigated to meet Armenia's energy needs. There is ongoing international discussion about the safety and future of this power plant.

The Metsamor Nuclear Power Plant, located in the Armenian city of Metsamor, raises serious concerns about safety and environmental effects, particularly for neighboring Azerbaijan.

Among Metsamor's effects on Azerbaijan are:

Environmental Concerns: The safety of the outdated Metsamor Nuclear Power Plant has drawn criticism. When this power station is operating, there is a chance that nuclear catastrophes similar to the Chernobyl tragedy could seriously pose a threat to the environment in the region, particularly in Azerbaijan.

Radiation Hazard: Any nuclear power plant poses a potential risk of radiation leakage. Radiation leakage can cause serious threats to the health of people and animals living in Azerbaijan.

Geological Risks: Metsamor is situated in Armenia, an area prone to frequent earthquakes. As a result, the NPP is more susceptible to earthquake dangers, which heightens Azerbaijan's concerns about a potential threat.

Azerbaijan demands that this NPP's operations be kept under strict control and that environmental concerns be maintained to a minimum.

Six nuclear reactors are currently in operation or will soon be put into service in our nation's neighboring countries. It is imperative to assess the potential radioactive fallout and radiation impact on our nation's territory resulting from any accidents in these nuclear reactors. For this reason, radiation anomaly maps for the region, including our nation, were simulated using "R Studio" software and C+ programming languages, taking into consideration the sites of nuclear reactors and the direction of the dominant air cyclones blowing in our area. Nevertheless, the metric system was used to project the distances onto the UTM map projection for our area of interest.

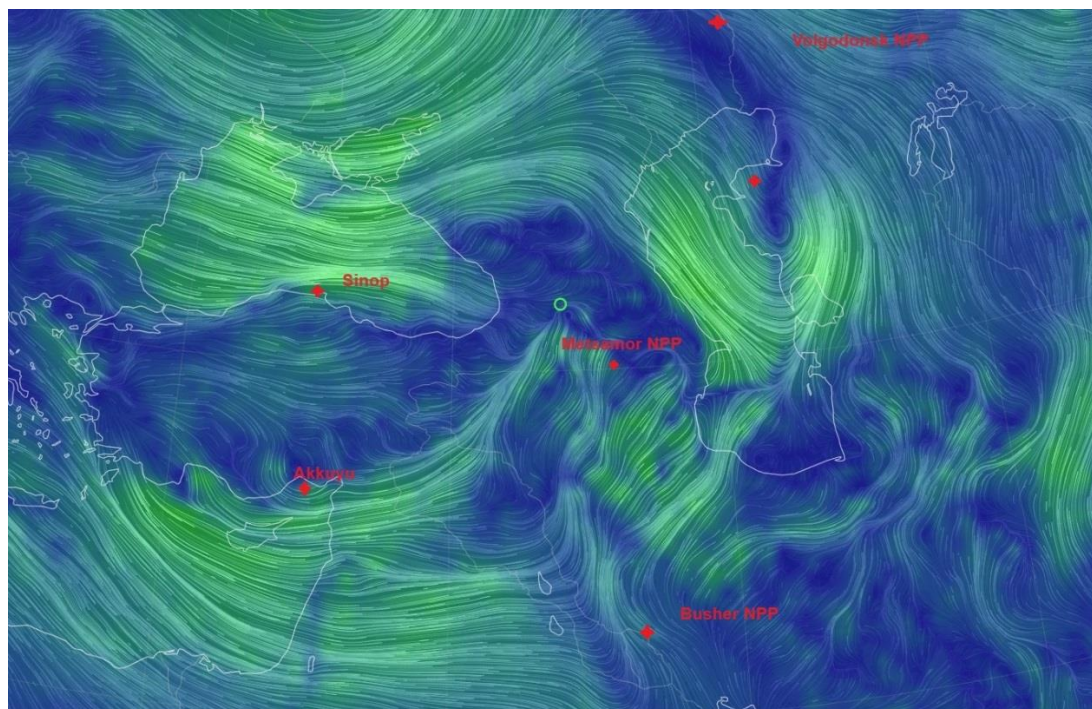


Fig. 2. Map of radiation anomalies caused by radioactive collapses during potential incidents at the nuclear reactors located in the region

For this purpose, the effect of the range variogram parameter was first determined. There was no nugget effect in this simulation; we used a spherical-plane model (Sph) at a range of 100

kilometers. We have provided a 2D simulation map of an area of 2000x3000 km for our region.

Tension in relations between Azerbaijan and Armenia has also been brought on by the ecological and safety issues in Metsamor. For this reason, Metsamor is a sensitive subject for Azerbaijan, encompassing not just energy-related matters but also safety and environmental ones.

2. Results

An essential concern is the management and prevention of nuclear radiation incidents. Applying the strictest safety regulations and quality control available globally is crucial for nuclear plants and technology. As a result, there will be less of a nuclear threat and nuclear technology will be safer. The extent of these measures is critical for the safety and readiness of nuclear plants and areas associated with radiological hazards. It should be remembered that preparatory work is very important in reducing the damage of a nuclear radiological accident. The exchange of safety information and guarantees and cooperation between countries and international organizations managing nuclear plants and technologies is essential. When it comes to using exceptional measures for nuclear radiological accidents, collaboration is crucial. Diverse strategies are needed to prevent nuclear radiological catastrophes, including compensation plans and readiness initiatives that boost environmental resilience and public safety.

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ВЛИЯНИЕ ВОЗМОЖНЫХ ЯДЕРНЫХ РАДИОЛОГИЧЕСКИХ АВАРИЙ, КОТОРЫЕ МОГУТ ПРОИЗОЙТИ НА АТОМНЫХ ЭЛЕКТРОСТАНЦИЯХ СОСЕДНИХ СТРАН, НА РАДИОЭКОЛОГИЮ РЕГИОНА

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Резюме: Ядерных радиологические инциденты могут иметь серьезные и долгосрочные последствия для окружающей среды. Потенциальное воздействие таких аварий на окружающую среду связано с утечкой радиоактивных материалов в атмосферу, почву и водные ресурсы. Радиоактивные вещества, попавшие в окружающую среду в результате ядерного излучения, могут накапливаться в почве. Подобное загрязнение может снизить плодородие почвы и повредить растительность. В долгосрочной перспективе такое загрязнение почвы может оказать негативное воздействие на сельское хозяйство и экосистемы. Ядерных радиологические инциденты могут привести к утечке радиоактивных химикатов в системы водоснабжения. Это может привести к загрязнению озер, рек и источников подземных вод. Загрязнение источников воды может отрицательно сказаться на доступности оросительной воды, а также на запасах питьевой воды. Радиоактивное загрязнение может повлиять как на растительный, так и на животный мир. Это может сократить популяцию видов, которые не могут противостоять радиации окружающей среды, и вызвать дисбаланс в экосистемах. Из-за длительного периода полураспада радиоактивных материалов загрязнение окружающей среды может сохраняться в течение нескольких лет и даже десятилетий. Это может иметь долгосрочные последствия для региона. Люди, находящиеся в непосредственной близости от места ядерной радиационной аварии, могут подвергнуться воздействию радиации. Это может привести к раку, генетическим мутациям и другим проблемам со здоровьем. Эвакуация или миграция людей, находящихся поблизости, может потребоваться в результате Ядерных радиологических аварий. В результате общины могут рассредоточиться и распасться.

По этим причинам крайне важно обеспечить безопасную эксплуатацию ядерных объектов, избежать утечек радиации и минимизировать радиационное загрязнение окружающей среды. Кроме того, важное значение для защиты окружающей среды имеют разработка и реализация планов действий в чрезвычайных ситуациях и стратегий реагирования на ядерные аварии.

Ключевые слова: ядерная авария, радиоэкология, атомные электростанции.

QONŞU ÖLKƏLƏRİN ATOM ELEKTRİK STANSİYALARINDA BAŞ VERƏ BİLƏCƏK MÜMKÜN NÜVƏ RADİOLOJİ QƏZALARIN REGIONUN RADİOEKOLOGİYASINA TƏSİRİ

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Xülasə: Nüvə radioloji qəzalarının ətraf mühitə təsiri ciddi və uzunmüddətli ola bilər. Bu cür qəzaların ətraf mühitə təsir etmə potensialı radioaktiv materialların atmosfərə, torpağa və su ehtiyatlarına sızması ilə əlaqədardır. Nüvə radiasiyası nəticəsində ətraf mühitə atılan radioaktiv maddələr torpaqda toplanı bilər. Bu çirklənmə torpağın münbitliyini azalda və bitki örtüyünə zərər verə bilər. Uzunmüddətli perspektivdə torpağın bu çirklənməsi kənd təsərrüfatına və ekosistemlərə mənfi təsir göstərə bilər. Radioaktiv maddələr nüvə radioloji qəzaları nəticəsində su ehtiyatlarına sızma bilər. Bu, göllərin, çayların və yeraltı su mənbələrinin çirklənməsinə səbəb ola bilər. Su mənbələrinin çirklənməsi həm içməli su mənbələrinə, həm də suvarma suyuna çıxışa mənfi təsir göstərə bilər. Radioaktiv çirklənmə bitki və heyvan həyatına təsir göstərə bilər. Bu, ekoloji radiasiyaya tab gətirə bilməyən növlərin populyasiyasını azalda bilər və ekosistemlərdə balanssızlığa səbəb ola bilər. Radioaktiv maddələrin yarı ömrü uzun olduğu üçün ətraf mühitin çirklənməsi illərlə və hətta onilliklərlə davam edə bilər. Bu, regiona uzunmüddətli təsirlərlə nəticələnə bilər. Nüvə radioloji qəzaları nəticəsində ətrafdakı insanlar radiasiyaya məruz qala bilər. Bu,

xərçəngə, genetik mutasiyalara və digər sağlamlıq problemlərinə səbəb ola bilər. Nüvə radioloji qəzalarından sonra ətrafdakı insanların evakuasiyası və ya miqrasiyası tələb oluna bilər. Bu, icmaların dağılmasına və yerdəyişməsinə səbəb ola bilər.

Bu səbəblərdən nüvə obyektlərinin təhlükəsiz istismarı, radiasiya sızmasının qarşısının alınması və ətraf mühitin radiasiya ilə çirklənməsinin minimuma endirilməsi böyük əhəmiyyət kəsb edir. Bundan əlavə, fəvqəladə hallar planlarının və nüvə qəzalarına qarşı cavab strategiyalarının hazırlanması və həyata keçirilməsi ətraf mühitin mühafizəsi üçün çox vacibdir.

Açar sözlər: nüvə qəzası, radioekologiya, atom elektrik stansiyaları.