Discussion on Effective Measures for Environmental Radiation Prevention and Protection

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Abstract: With the progress of science and technology and the wide application of nuclear energy, environmental radiation has become an important issue of global concern. The leakage of radioactive materials, the disposal of radioactive waste and the management of radioactive sources directly affect public health and ecological safety. From four dimensions of radioactive source management, monitoring technology, emergency response and public education, this paper will analyze in detail the current effective measures for environmental radiation prevention and protection, verify their effectiveness through data and cases, and strive to provide new ideas and feasible programs for achieving a safer living environment.

Keyword: Environmental Radiation; Prevention and Protection; Measure Application

1. Introduction

In modern society, the application of radioactive substances has penetrated into many fields, including medical, industrial, scientific research and energy, etc., however, with the accompanying environmental radiation risks are increasingly significant. The leakage, misuse and improper disposal of radioactive materials not only have an immediate impact on ecosystems, but can also pose a long-term threat to human health. The International Atomic Energy Agency (IAEA) and the World Health Organization (WHO) have pointed out that the frequency of radioactive contamination incidents is increasing year by year, and the public's awareness and response capacity are still insufficient. In this context, effective measures for environmental radiation prevention and protection are particularly important^[1-2].

The status of radiological preventive

protection is an area of universal attention in the world. With the wide application of radiological technology in medical, industrial, scientific research and other fields. radiological protection measures have been significantly strengthened. Internationally, the guidelines issued by the International Commission on Radiological Protection (ICRP) provide an important reference for countries to formulate radiological protection standards. Governments also ensure the health and safety of the public and radiological workers through legislation and standards. For example, radiological protection in the medical field is achieved by optimizing imaging procedures, using dose management software, and wearing personal dose monitors. Industry and scientific research have also taken strict protective measures, such as the establishment of radiation safety zones, the implementation of regular training and monitoring. Nevertheless, with the emergence of new technologies, protection still faces new radiological challenges, and continuous research and international cooperation are needed to further improve the protection system^[3-5]

2. Management of Radioactive Sources in Environmental Radiological Prevention and Protection

In environmental radiation prevention and protection, radioactive source management is a link, involving strict control and kev supervision of radioactive substances, ensuring their safe use, and preventing radioactive and radiation accidents. pollution This includes the comprehensive management of the registration, storage, transportation, use and disposal of radioactive sources, as well as the training and health care of relevant personnel, to ensure compliance with national radioactive material safety standards and regulations, and to protect the public and the environment from unnecessary radiation risks.

The scientific management of radioactive sources is a fundamental aspect of the prevention of environmental radiation, including the strict control of radioactive sources throughout their life cycle, including production, use, storage and disposal. Effective management helps prevent leakage, misuse and any potential events that may adversely affect human health and the environment. For an illustration of the current global management of radioactive sources, see Table 1 below:

District	Number of radioactive	Management compliance	Annual leakage events
District	sources (unit: 10,000)	rate (%)	(events that occur)
North America	12	95	2
Europe	9	96	1
Asia	15	90	3
Africa	4	80	5
South America	5	85	4

Table 1. Global Status of Radioactive	Source Management
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As is evident from Table 1, regions with mature radioactive source management systems show higher compliance rates, with North America and Europe reporting compliance rates of 95% and 96%, respectively, and lower annual leakage events (2 and 1, respectively), while regions such as Africa have compliance rates of only 80%, which are associated with more leakage events (5 occurrences). The data show a clear relationship: as compliance rates increase and the frequency of leaks tends to decrease, there is an urgent need to establish and enforce international regulatory standards governing the management of radioactive sources, which should include security protocols, operational guidelines, and reporting mechanisms to promote higher global compliance and strengthen global collaborative facilitation processes among countries^[6-8].

Implementing a life cycle management approach includes the management of radioactive sources from the beginning of life to the end of life and should include detailed tracking and documentation: (1) Production: ensuring that materials are procured responsibly and safety procedures are followed from the manufacturing stage. (2) Usage: Establish a strict monitoring mechanism during use to confirm compliance with safety regulations and identify any abnormal conditions. (3) Storage: Specify secure storage facilities to protect against unauthorized access and potential accidental exposure. (4) Waste disposal: Establish standardized practices for the safe disposal of radioactive waste to ensure that it does not pose risks to the environment or human health.

Personnel involved in radioactive source

management should undergo an ongoing training programme focusing on safety procedures, emergency response and regulatory compliance, with regular internal and external audits to ensure compliance with established guidelines and to identify areas for improvement. Effective management of radioactive sources is key in the field of preventive environmental radiation protection, and significantly reducing the risks posed by radioactive sources through the establishment of harmonized regulatory standards, the implementation of life cycle management practices, and regular training and audits, continuous improvement, together with community participation, will contribute to a safer environment for all.

3. Monitoring Technology in Environmental Radiological Prevention and Protection

Advanced monitoring technology plays a crucial role in early detection and timely response to radiation leakage, and the effectiveness of the technology depends on the detection accuracy, data transmission rate and real-time monitoring capability. In order to illustrate the functions of various monitoring technologies, the performance indicators are compared and analyzed in Table 2.

From the data shown in Table 2, it is clear that spectral analysis technology is superior to other monitoring technologies in terms of detection accuracy and real-time response, with A detection accuracy of $0.02 \ \mu$ Sv/h and reporting data in 0.3 seconds, radiation detector B provides significant accuracy and a fast response time of 0.5 seconds, while other solutions, such as drone monitoring and radiation detector A, provide significant Journal of Safety Science and Engineering (ISSN: 3005-5814) Vol. 1 No. 4, 2024

accuracy and a fast response time of 0.5 seconds. Show less impressive performance metrics. The ability to quickly and accurately

detect radiation levels is essential for initiating effective response plans that effectively ensure public safety and environmental protection.
 Table 2. Advanced Detection Technology and Detection Accuracy

Technology	Detection accuracy(μ Sv/h)	Data transfer rate(MB/s)	Real-time response(s)		
Radiation detector A	0.1	5	1		
Radiation detector B	0.05	10	0.5		
Spectral analysis technique	0.02	15	0.3		
Drone monitoring	0.1	8	2		

When the radiation level exceeds the preset threshold of 0.05 μ Sv/h, the system is able to respond quickly and activate an emergency plan within 2 minutes to ensure the safety of surrounding residents. In an environmental monitoring project, the drone team conducted radiation tests over a 2 km² area and found local radiation levels of 0.15 µSv/h. The data is transmitted to the central control system in real time, and the necessary on-site emergency measures are taken within 30 minutes to effectively mitigate potential hazards. By utilizing artificial intelligence technology, the monitoring center can analyze information from each sensor in real time, identifying abnormal patterns through complex algorithms. For example, in the course of a prolonged monitoring of a particular city, the AI system recorded up to 120 abnormal data points, 60% of which were due to human malpractice. This insight led to the development of a data-driven automatic alarm system designed to significantly reduce human error. Bv integrating radiation monitoring data from the past five years, the research team determined that during a given period of time, For example, when the summer temperature is high, the radiation level tends to be higher. The introduction of satellite remote sensing technology has further enhanced the prediction capability, increasing the accuracy rate by up to 20%. A new generation of sensors with a 30% increase in sensitivity allows for the detection of extremely low radiation levels and can be reduced to 0.01 μ Sv/h, and the development of portable monitoring devices aims to reduce the size and weight of the devices, thereby improving their usability in a of environments. varietv thus making monitoring more accessible and efficient in different operating environments^[9]. In the field of environmental radiation prevention and protection, the continuous innovation and

development of monitoring technology is the key to promote the improvement of safety protection capabilities. In addition to several advanced monitoring technologies mentioned above, some emerging technologies are gradually applied to practice to further enhance the monitoring and response ability of environmental radiation risks.

4. Emergency Response in Environmental **Radiological Prevention and Protection**

Sound emergency response mechanisms are essential to mitigate the environmental and public health effects of radiological events, and by responding quickly to incidents, it is possible to limit environmental contamination, safeguard human health and ensure a rapid return to normalcy. The nature and urgency of different radiological events require tailored response strategies, which must be informed by real-time data and precise planning. To better understand the effectiveness of various emergency responses. Table 3 Outlines several types of radiological events, their respective response times, potential levels of and environmental contamination, the estimated number of people directly affected. The data in Table 3 illustrates the relationship between emergency response time and the resulting impact on the environment and public health. A nuclear power plant leak, requiring a 10-minute response time, could lead to contamination of a 5 km² area, directly affecting approximately 10,000 people. In contrast, medical radiation incidents have a short response time of only 5 minutes, affecting an area of only 0.1 km² and about 500 people, and the efficiency of emergency response becomes increasingly important as the potential consequences of delayed action can escalate rapidly. It is essential to establish science-based emergency response plans, including complex contingency plans for each

type of radiological event, supported by simulation and predictive modelling, and frequent simulation exercises should be conducted to ensure that emergency personnel are well practiced in implementing the contingency plan. The exercise assesses preparedness and improves protocols based on real-time feedback and performance indicators, enhances the integration and scheduling of emergency resources across different agencies, and ensures effective coordination of response efforts, including a database for the rapid deployment of personnel and equipment to affected areas. Improve situational awareness and response speed by mapping resources and potential impact areas using geospatial information systems (GIS), an approach that allows for rapid allocation of resources based on predicted contamination patterns after an event.

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Type of radioactive event	Response	Environmental	Number of people directly affected
Type of factoactive event	time(min)	pollution range(km ²)	(Per 10,000 people)
Nuclear power plant leakage	10	5	1
Medical radiation accident	5	0.1	0.05
Loss of industrial radioactive	15	0.5	0.2
sources			0.2
Natural radiation burst	8	2	0.5

Table 3. Emergency Response Time and Scope of Impact

Public education programmes on radiation safety, potential risks and emergency response operations to enable communities to take effective action during crises and to establish reliable channels of information dissemination in emergency situations are essential. Channels should provide real-time updates on protective measures and response actions to minimize panic and confusion, and after any major radiological event, conduct thorough debriefing sessions to learn from the incident. Analyzing response effectiveness, resource allocation, and public communication will lead to continuous improvement in response capacity, leveraging feedback from affected communities to inform ongoing training and program adjustments, and ensuring that lessons learned are incorporated into future preparedness efforts.

5. Public Education in Environmental Radiological Prevention and Protection

Increased public awareness of radiation is essential to ensure that the public has the capacity to protect itself against radiation risks and that an informed population is better equipped to respond appropriately in the event of a radiation event, leading to more effective preventive measures and greater community resilience. Public education on environmental radiation includes a variety of factors, including knowledge of potential sources of radiation, awareness of the health effects of exposure, and knowledge of appropriate protective actions. Table 4 shows a survey that assesses public knowledge about radiation in regions, different revealing significant differences in understanding and awareness.

District	Survey Number	Basic understanding of proportion	Detailed comprehension scale
District	(personnel)	(%)	(%)
North America	1000	70	40
Europe	1000	65	35
Asia	1000	50	20
Africa	1000	40	15
South America	1000	45	18

 Table 4. Public Knowledge Survey on Radiation Knowledge

From the data described in Table 4, it is clear that the level of public knowledge about radiation varies greatly in different regions. In North America, the proportion of individuals with basic knowledge about radiation is 70%, among which the proportion of individuals with detailed knowledge is 40%, while the level of awareness is significantly lower in

Africa, where only 40% of people have basic knowledge about radiation concepts and only 15% have detailed knowledge. South America and Asia also reflect low levels of understanding, underscoring the need for targeted educational initiatives and the importance of using varietv а of communication channels, such as social media

campaigns, community workshops, school projects and public service announcements, to effectively disseminate radiated knowledge. This multifaceted approach will promote broader coverage and participation, developing content tailored to different demographics to understanding, improve for example, simplifying complex scientific terms and using relatable analogies to ensure that material is accessible to all ages and educational backgrounds^[10]. Actively involve the community environmental radiation in protection activities, such as awareness campaigns, exercises and clean-up activities, to develop a sense of ownership and responsibility. Participation Strengthening knowledge, awareness and self-protection through practical experience, establishing local clubs focused on radiation safety providing continuous learning opportunities, holding expert lectures, workshops and interactive sessions where members actively participate in discussions and learning exercises.

6. Conclusion

To sum up, environmental radiation prevention and protection measures are complex systems engineering, involving radioactive source management, monitoring technology, emergency response and public education and other aspects, effective radioactive source management can not only ensure the safety of radiation sources in the production, use, storage and disposal process, but also prevent potential leakage and misuse, thereby reducing the harm to the environment and human health. In the future development, it is necessary to continuously improve the existing measures, with the help of new technological progress and innovation of scientific research to cope with the increasingly complex environmental radiation challenges, in order to ensure the safety and health of human and natural environment.

Environmental radiation protection is an important measure to protect people's life and health and ecological environment safety. In order to effectively strengthen the safety management of environmental radiation and ensure the safety of the radiation environment, adhere to scientific planning and reasonable layout, strictly control the scope of use of radioactive substances, adopt advanced closed systems and shielding technology, effectively reduce radiation leakage, and implement strict safe handling and storage measures for radioactive waste. Establish а sound environmental radiation monitoring network, regularly monitor environmental radioactivity levels, and conduct comprehensive radioactive pollution monitoring of water sources, soil, air and living organisms to ensure timely detection and treatment of abnormal radiation. China has extensively popularized radiation protection knowledge, raised the public's awareness of radiation hazards, conducted professional training and safety education for personnel engaged in radioactive work, formulated and practiced emergency plans for radiation accidents, and improved emergency response capabilities. To formulate and improve relevant laws and standards on radiation protection, ensure that all radioactive activities strictly abide by laws and regulations, and seriously deal with violations of radiation protection provisions in accordance with the law. Establish and improve the emergency response mechanism for radiation accidents, prepare necessary emergency supplies and equipment, and ensure that effective measures can be taken promptly in the event of radiation accidents to minimize the risk of radiation personal exposure. Provide necessary equipment protective for workers in radioactive work areas, educate the public to take appropriate protective measures in a radiation environment. strictly manage radioactive work areas, and prevent non-workers from entering. In the design stage of radioactive facilities, the need for radiation protection should be fully considered, sensitive areas such as residential areas and schools should be reasonably planned, far away from radioactive sources, and necessary radiation protection modifications should be carried out on existing buildings. Actively participate in international exchanges of radiation protection information and technology, participate in the formulation of international radiation protection standards, and strengthen international cooperation and assistance in transnational radiation accidents.

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