

Current Situation and Countermeasures of Radiation Environmental Management in Grassroots Ecological and Environmental Departments

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Abstract: With the rapid development of nuclear technology applications, the regulatory burden on grassroots-level radiation environmental supervision has become increasingly onerous. Drawing on the practical experience of grassroots-level ecological and environmental departments, this paper systematically examines the practical challenges faced in radiation environmental management regarding institutional structures, personnel, technical support and regulatory mechanisms. It proposes targeted countermeasures from the perspectives of capacity building, institutional innovation and smart regulation, thereby providing guidance for enhancing the standard of grassroots-level radiation environmental management.

Keywords: Grassroots Ecological and Environmental Departments; Radiation Environmental Management; Regulatory Capacity; Countermeasures

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1. Introduction

Nuclear and radiation safety is closely linked to national security, environmental safety and public health. In recent years, with the rapid development of industries utilising nuclear technology—such as medical radiology, industrial radiography and irradiation processing—the number of radioactive sources and radiation-emitting devices has increased year on year, and radiation environmental safety issues have gradually become a focal point of public concern^[1].

Against this backdrop, grassroots ecological and environmental departments bear important responsibilities such as day-to-day radiation safety supervision, licence management and emergency response. However, the contradiction between increasingly onerous regulatory tasks and insufficient grassroots regulatory capacity is becoming increasingly prominent. Problems such as a large number of regulatory targets, a wide scope of coverage, weak professional expertise and insufficient technical support are widespread. How to optimise the radiation environmental management model and enhance regulatory effectiveness based on grassroots realities has become an important issue that urgently requires research and resolution^[2].

This paper focuses on the radiation environmental management practices of grassroots ecological and environmental departments. Building upon a summary of the current situation, it analyses the principal issues at hand and proposes practical and feasible recommendations, with the aim of providing guidance for strengthening grassroots radiation environmental management^[3].

2. Current Status of Radiation Environmental Management at the Grassroots Level

2.1 Continuous Increase in Regulatory Targets

With economic and social development and the expansion of nuclear technology applications, the number of grassroots entities utilising nuclear technology has shown a sustained growth trend. Taking Kunming City as an example, by the end of 2024, there were a total of 1,533 radiation-regulated entities with valid radiation safety licences across the city, accounting for approximately 30% of the provincial total. The regulatory burden is significant due to the large number of entities, the wide variety of types, and the heavy workload. In the medical sector, the use of radiation equipment is becoming increasingly widespread, ranging from large general hospitals to township health centres, dental clinics and veterinary clinics. These entities are widely distributed and diverse in nature, ranging from enterprises using high-risk radioactive sources to small medical institutions using only Class III radiation equipment; the complexity and diversity of the entities subject to supervision present challenges for grassroots management^[4].

2.2 Regulatory Responsibilities Are Gradually Being Clarified

In terms of institutional structure, some prefectural-level ecological and environmental departments have established dedicated radiation environmental management bodies responsible for leading radiation environmental management work within their jurisdictions. At the county level, most have not yet established independent departments, and radiation regulatory functions are typically undertaken by general departments or law enforcement agencies. Some regions are actively exploring the establishment of a ‘three-tiered coordination’ regulatory framework, with provincial-level authorities providing overall supervision and guidance, and prefectural- and county-level authorities responsible for specific implementation, gradually forming a regulatory system that integrates online and offline responsibilities^[5].

2.3 Continuous Innovation in Management Approaches

Leveraging the National Radiation Safety Supervision System for Nuclear Technology Applications, grassroots authorities are gradually implementing a combined “online + offline” regulatory model. Through system data verification and the handling of early warning information, remote supervision of entities utilising nuclear technology is being achieved. Some regions are exploring the establishment of online monitoring systems for high-risk radioactive sources, utilising Internet of Things (IoT) technology to track the location and dose rate levels of radioactive sources in real time, thereby providing technical support for precise supervision. At the same time, certain regions are innovatively implementing a “seamless supervision” model, which involves real-time verification and intelligent early warning for nascent issues such as expired enterprise training qualifications or overdue annual assessment reports, thereby achieving “prevention before violations occur”.

3. Major Issues

3.1 Insufficient Regulatory Capacity

Insufficient radiation regulatory capacity at the grassroots level is a widespread and prominent issue. On the one hand, there is a severe shortage of personnel; the number of staff dedicated to radiation regulation at the municipal and county levels is limited, with most staff members “holding multiple roles”, making it difficult to ensure sufficient focus on radiation regulatory work. Some counties and districts do not even have full-time radiation supervision staff, with radiation safety supervision treated merely as an ancillary task. Taking Sanmen County as an example, the staffing levels and structure of technical personnel at the County Environmental Protection Monitoring Station fall short of national construction standards, and no dedicated position for radiation environmental monitoring has been established; all radiation health monitoring staff at the County Centre for Disease Control and Prevention are part-time, resulting in a severe shortage of professional expertise. Furthermore, professional capabilities require improvement. Radiation supervision involves specialised knowledge in fields such as nuclear physics and radiation protection, yet grassroots staff generally have low educational qualifications and lack a background in relevant disciplines. Their daily work relies primarily on accumulated experience, and they often find themselves ill-equipped when faced with highly specialised inspection and supervision tasks.

3.2 Weak Technical Support

Radiation monitoring is a fundamental tool for radiation environmental management, yet technical support capacity at

the grassroots level is markedly inadequate. Firstly, there is a shortage of monitoring equipment; county-level ecological and environmental departments are generally not equipped with the necessary radiation monitoring instruments, and even where they are, the quantities are limited and the equipment is outdated, making it difficult to meet the requirements for comprehensive and accurate monitoring. Secondly, funding is a major constraint; limited funds make it difficult to support equipment upgrades and maintenance or the introduction of new technologies, and also hinder the conduct of professional training and emergency drills. Some counties and districts even have to rely on municipal monitoring resources to carry out routine surveillance monitoring tasks.

Thirdly, there is a lack of laboratory capacity. Grassroots monitoring stations generally lack dedicated radiation monitoring laboratories, and laboratory analytical capabilities for key nuclides such as tritium and carbon-14 are virtually non-existent. Existing capabilities cover only basic indicators such as X- and gamma-ray radiation dose rates, making it difficult to meet comprehensive regulatory requirements.

3.3 Regulatory Mechanisms Are Not Sufficiently Streamlined

Insufficient coordination between regulatory and law enforcement bodies is a key factor affecting regulatory effectiveness. Although municipal radiation environmental management agencies bear regulatory responsibilities, they often lack the legal standing to enforce the law and must refer cases of illegal activity to law enforcement departments for handling. There is a degree of information disconnect and poor coordination between regulatory and law enforcement departments.

Furthermore, radiation safety supervision involves multiple departments, including ecological environment, health, and public security, yet coordination mechanisms between these departments remain underdeveloped. Inspections have revealed that issues such as the improper operation of radiation safety and protection facilities, inadequate implementation of radiation management systems, and insufficient occupational health management in some units require a multi-departmental collaborative approach to resolve.

3.4 Low Level of IT Application

Although the National Radiation Safety Supervision System for Nuclear Technology Utilisation has been rolled out, issues such as incomplete data reporting and untimely updates persist at the grassroots level during actual use. Some nuclear technology utilisation units are unfamiliar with the system's operation, resulting in missing or outdated key data such as unit information, personnel details and equipment records. The 2025 'double-random' radiation safety inspection in Xiangyang City revealed that some units had failed to promptly upload information regarding monitoring instruments, personal protective equipment, individual radiation worker dose records and training records.

At the same time, the analysis and application of system data are not sufficiently in-depth, and the system has not yet fully realised its potential to support regulatory decision-making. An automated monitoring network has not yet been established; data management relies on manual operations, and there is a lack of a unified intelligent analysis platform.

4. Recommendations

4.1 Strengthening Capacity Building at the Grassroots Level

Enhancing grassroots radiation environmental management capabilities requires a multi-pronged approach. Regarding workforce development, the number of dedicated staff should be appropriately increased in line with practical needs to ensure that every task has a designated manager and every responsibility has a designated bearer. In terms of professional training, a regularised training mechanism should be established, adopting a capacity-building model that combines 'bringing in experts and sending staff out for training' with 'teaching professional skills and methods' and 'identifying problems and prioritising rectification'. A pre-meeting legal study system should be implemented, and regular training sessions on standardised radiation environmental management should be held, inviting experts to deliver lectures and innovatively organising regional standardised management drills and assessments.

Regarding financial support, we actively seek fiscal backing to procure essential regulatory equipment and monitoring instruments, thereby providing fundamental support for regulatory work. We strengthen the capacity-building of monitoring stations, advance laboratory development, and ensure adequate stockpiling of emergency supplies.

4.2 Improving Coordination and Collaboration Mechanisms

We will refine internal coordination and external collaboration mechanisms to foster a concerted regulatory effort. Internally, we must strengthen the coordination between regulatory and law enforcement functions, establishing working mechanisms for information sharing, the transfer of leads and joint inspections to resolve issues of ‘inability to regulate or regulate effectively’. Externally, we must improve collaboration mechanisms with departments such as public security and health, enhancing information sharing during the transfer, use and decommissioning of radioactive sources, conducting joint inspections, formulating cross-departmental enforcement lists, and carrying out ‘comprehensive one-off’ joint inspections targeting key hazards to eliminate multiple and duplicative enforcement actions.

4.3 Promoting Categorised and Refined Management

Implement categorised management of entities utilising nuclear technology based on radiation safety risk levels. For entities using high-risk radioactive sources or mobile radiographic inspection equipment, implement key supervision, increase inspection frequency, and strengthen on-site verification; for low-risk entities using only Class III radiation-emitting devices, conduct off-site supervision via the regulatory system, urging rectification through data verification and early warning tracking to achieve the principle of “leaving law-abiding entities undisturbed whilst ensuring violations are investigated”.

At the same time, addressing the challenge of weak radiation safety foundations in small medical institutions such as dental and veterinary clinics, a “tailored approach for each facility” has been implemented to provide targeted support. Through on-site visits and guidance, customised solutions for record management and the upgrading of protective facilities are developed for small clinics, alongside a comprehensive “application–rectification–licensing” assistance service.

4.4 Enhancing Smart Regulatory Capabilities

Fully utilising information technology to enhance regulatory efficiency. Firstly, strengthening data quality management within the National Radiation Safety Supervision System for Nuclear Technology Applications, urging entities utilising nuclear technology to report information promptly and accurately, thereby improving the completeness and accuracy of system data. Relying on the national data platform, implementing dynamic monitoring and management of the entire process—including the declaration, use and storage of radioactive sources—to establish an online, end-to-end closed-loop safety supervision model.

Secondly, we are exploring the application of Internet of Things (IoT) technology to implement real-time tracking and dose monitoring of high-risk mobile radioactive sources, and have completed the installation and commissioning of an online monitoring system for fixed radioactive sources, thereby enabling end-to-end tracking from the moment they leave the warehouse until they are returned. Thirdly, we are utilising big data analysis to support regulatory decision-making, accurately identify risk points, and enhance the targeted nature of our regulatory efforts.

4.5 Strengthening Emergency Response Capabilities

Radiation accident emergency response is the last line of defence for environmental safety. Grassroots units should revise and refine radiation accident emergency response plans in line with local conditions, clearly defining response procedures and the division of responsibilities. Regular emergency drills should be organised, employing methods such as ‘blind drills’ to test operational capabilities. For instance, Zhangbei County organises an annual radiation accident emergency drill for key units; in December 2025, a script-free, full-scale emergency drill was conducted, simulating a lost radioactive source incident and carrying out a comprehensive simulation of emergency response decision-making and command and coordination procedures.

Strengthen the stockpiling of emergency supplies and the development of response teams, and enhance professional training for monitoring technicians to achieve a 100% certification rate, ensuring a rapid response and effective handling in the event of an incident.

5. Conclusions

Radiation environmental management at the grassroots level constitutes the ‘last mile’ of the nuclear and radiation safety regulatory system; its effectiveness is directly linked to the healthy development of nuclear technology applications and public environmental safety. Currently, grassroots-level supervision faces practical challenges such as insufficient personnel, weak technical support and inefficient mechanisms. It is necessary to gradually establish a scientific and efficient radiation

environmental management system that is suited to grassroots realities through measures such as strengthening capacity building, improving coordination mechanisms, promoting refined management and enhancing smart capabilities, thereby effectively fortifying the nuclear and radiation safety defence line.

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Conflict of Interests

The authors declare that there is no conflict of interest regarding the publication of this paper.

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