GOLDEN RATIO OF LAW AND SOCIAL POLICY REVIEW
VOLUME 6, ISSUE. 1 (2026)
Website: https://goldenratio.id/index.php/grlspr

GOLDEN RATIO
ISSN [Online]: 2808-2923

LAW & SOCIAL POLICY | RESEARCH ARTICLE

Environmental Legal Liability for Radioactive Contamination in Exported Frozen Shrimp Products in the Cikande Industrial Area

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ARTICLE HISTORY

Received: June 12, 2026
Revised: July 02, 2026
Accepted: July 05, 2026

DOI
https://doi.org/10.52970/grlspr.v6i1.2381

ABSTRACT
The detection of radioactive Cesium-137 (Cs-137) contamination in Indonesian exported frozen shrimp products in 2025 raised concerns over environmental protection, food safety, consumer protection, and international trade sustainability. This study analyzes environmental legal liability for radioactive contamination in the fishery industry supply chain in the Cikande Industrial Area and examines legal protection for consumers, workers, surrounding communities, and affected business actors. This study uses normative legal research with statutory, conceptual, and case approaches. The legal materials include regulations on environmental protection, consumer protection, nuclear energy, radiation safety, and food safety. The findings show that Cs-137 contamination indicates weak implementation of the precautionary principle, inadequate supervision of radioactive hazardous waste, and limited cross-agency coordination. Legal liability should be constructed through strict liability and the polluter pays principle, requiring the polluting party to bear restoration, compensation, and victim recovery costs. This study recommends strengthening radioactivity supervision, improving inter-agency coordination, and establishing risk-based preventive monitoring to ensure food safety, environmental protection, and sustainable fishery exports.

Keywords: Radioactive Contamination, Cesium-137, Exported Frozen Shrimp, Environmental Law.

I. Introduction

The fisheries sector is one of Indonesia's strategic economic pillars due to its significant contribution to national food security, employment generation, and foreign exchange earnings through export-oriented activities. Among fishery commodities, shrimp represents one of the most valuable export products in international trade markets. The competitiveness of Indonesian shrimp exports is not determined solely by production capacity and pricing, but also by compliance with food safety standards, environmental sustainability, traceability systems, and regulatory conformity with importing countries' legal frameworks (Putra & Saptanto, 2020). In the context of global food trade, regulatory standards for exported food products have become increasingly stringent, particularly concerning contamination risks involving heavy metals, toxic substances, pathogenic agents, and radioactive materials. Radioactive contamination is considered one of the most serious environmental and public health threats due to its persistence, invisibility, and long-term biological effects. One of the most hazardous radionuclides is Cesium-137 (Cs-137), an artificial radioactive

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isotope produced through nuclear fission processes. Cs-137 has a relatively long half-life and is capable of dispersing through environmental media such as air, soil, water, sediment, and aquatic ecosystems, thereby entering the food chain, including marine biota such as shrimp (International Atomic Energy Agency [IAEA], 2019; WHO, 2020). Recent findings of Cs-137 contamination in Indonesian exported frozen shrimp products in 2025 have raised serious concerns regarding the intersection between environmental governance, food safety regulation, and international trade compliance. This incident indicates that contamination in food export commodities cannot be understood solely as a technical or industrial hygiene issue, but must also be examined as a legal issue involving environmental liability, state regulatory responsibility, and consumer protection within a complex supply chain system. The emergence of radioactive contamination in fishery products also demonstrates that environmental risks are inherently cross-sectoral and cross-media in nature. In many cases, contamination does not originate directly from fishery activities, but may be associated with supporting industrial activities such as improper handling of scrap metal, hazardous materials, or radioactive-contaminated industrial inputs. Without adequate radiation monitoring systems, such substances may spread through industrial estates and ultimately affect food production chains. This condition reflects the need for integrated environmental supervision involving multiple sectors beyond fisheries alone (Fathurrahman, 2020; Ramadhan et al., 2023).

From a public health perspective, radioactive contamination presents unique challenges because it is not detectable through sensory observation. Consumers cannot identify contamination through appearance, smell, or taste, which increases exposure risk. Long-term ingestion of radioactive substances such as Cs-137 may cause severe health effects, including cellular damage, organ dysfunction, and increased cancer risk (WHO, 2020). Therefore, legal protection mechanisms must prioritize preventive measures through environmental monitoring, product testing, and supply chain traceability, rather than relying solely on post-damage compensation mechanisms. Indonesia has established a normative legal framework relevant to environmental protection, radioactive safety, food safety, and consumer protection. Law Number 32 of 2009 concerning Environmental Protection and Management provides foundational principles such as state responsibility, precautionary principle, polluter pays principle, and strict liability for hazardous activities. Meanwhile, Law Number 10 of 1997 concerning Nuclear Energy, as amended by Law Number 6 of 2023, regulates the supervision of radioactive materials under the authority of the Nuclear Energy Regulatory Agency (BAPETEN). Additionally, Law Number 8 of 1999 concerning Consumer Protection guarantees consumer rights to safety, security, and accurate information. These regulatory frameworks indicate that radioactive contamination in exported food products engages multiple overlapping legal regimes, including environmental law, nuclear law, food safety law, and consumer protection law. However, despite the existence of these legal instruments, implementation challenges remain significant. Regulatory supervision of radioactive substances, food safety systems, and export commodities is still characterized by institutional fragmentation involving multiple agencies, including BAPETEN, the Ministry of Environment and Forestry, the National Agency of Drug and Food Control (BPOM), and the Ministry of Marine Affairs and Fisheries. This fragmentation creates potential regulatory gaps, particularly in early detection, enforcement coordination, and crisis response mechanisms. In cases involving cross-sectoral contamination such as Cs-137 exposure, effective governance requires strong inter-agency coordination and integrated monitoring systems (Putra, 2021; Wahyuni, 2020).

The detection of Cs-137 contamination in exported frozen shrimp products linked to the Cikande Industrial Area highlights a significant gap between normative legal frameworks and empirical enforcement practices. This case has implications not only for Indonesia's export reputation but also for legal accountability mechanisms in environmental law. The core legal issue lies in determining environmental liability, including identification of responsible parties, causal relationships between industrial activity and contamination, and appropriate legal mechanisms for liability allocation. Under environmental law principles, liability in radioactive contamination cases may be constructed through strict liability and the polluter pays principle, particularly due to the complex, cross-media, and scientifically difficult nature of proving fault in environmental harm. These principles ensure that responsible actors bear the costs of environmental

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restoration, compensation, and victim recovery without requiring proof of negligence in conventional terms. Previous studies have addressed environmental liability, radioactive waste management, and inter-agency regulatory coordination in Indonesia from various perspectives (Fathurrahman, 2020; Hidayat, 2023; Wahyuni, 2020). However, limited research has specifically examined the integration of strict liability, polluter pays principle, and multi-actor accountability in cases of radioactive contamination in exported fishery products within industrial estate contexts such as Cikande. Moreover, recent scholarship emphasizes the importance of reconstructing liability models in environmental governance to ensure legal certainty and effective enforcement in corporate and industrial activities (Pratama & Sulaiman, 2026; Sugiarto, 2025). Based on this gap, this study focuses on environmental legal liability for radioactive contamination in exported frozen shrimp products in the Cikande Industrial Area. Using a normative legal research approach, this study analyzes statutory regulations, legal principles, and case-based interpretation within the framework of environmental and nuclear law. The research questions addressed are: (1) how the chronology of Cs-137 contamination can be analyzed from an environmental law perspective; (2) which legal provisions are relevant and potentially violated in the fishery supply chain; (3) how environmental legal liability is constructed under applicable legal principles; and (4) what forms of sanctions and legal protection can be imposed for affected stakeholders, including consumers, workers, surrounding communities, and business actors. Accordingly, this study is expected to contribute both theoretically and practically to strengthening environmental governance, improving radioactive contamination control, enhancing consumer protection mechanisms, and supporting the sustainability of Indonesia's fishery export industry.

II. Literature Review and Hypothesis Development

2.1. Environmental Law and Liability for Pollution

Environmental law is a legal instrument that regulates the relationship between humans, business activities, and the environment in order to ensure that development activities do not cause ecological damage or harm to society. In the Indonesian context, the primary legal basis of environmental law is Law Number 32 of 2009 concerning Environmental Protection and Management. This law places environmental protection as the responsibility of the state, business actors, and society, while also regulating instruments of prevention, supervision, law enforcement, and environmental restoration. Environmental legal liability has a different character from ordinary civil liability. In environmental pollution cases, proving fault is often difficult because pollution may occur in a complex manner, across different environmental media and sectors, and may involve many actors within an industrial activity chain. Therefore, environmental law recognizes the principle of strict liability. This principle allows business actors to be held liable for environmental damage without first requiring proof of fault. In Indonesian law, this principle is reflected in Article 88 of Law Number 32 of 2009, which provides that any person whose activities involve hazardous and toxic substances, produce or manage hazardous and toxic waste, and/or pose a serious threat to the environment shall be strictly liable for the losses incurred. Strict liability is particularly important in cases of radioactive pollution because radioactive waste falls within the category of high-risk waste. Radioactive pollution may spread through air, soil, water, and the food chain, making it difficult for victims to directly prove the causal relationship between the source of pollution and the losses suffered. Rianda (2021) explains that the principle of strict liability in environmental law is intended to strengthen ecological protection and ease the burden of proof for victims in pollution cases. Accordingly, in cases involving Cesium-137 (Cs-137) contamination, strict liability may serve as a more effective basis of legal responsibility than an ordinary unlawful act claim under Article 1365 of the Indonesian Civil Code. In addition to strict liability, environmental law also recognizes the polluter pays principle. This principle places the polluter as the party responsible for bearing the costs of prevention, mitigation, restoration, and compensation for environmental damage caused by its activities. This principle is relevant in radioactive pollution cases because the costs of environmental restoration, laboratory testing, decontamination, community relocation, health examinations, and economic losses suffered by other

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business actors can be substantial. Under the polluter pays principle, the burden of restoration should not be shifted to the state or society, but should be borne by the party responsible for causing the pollution.

2.2. The Precautionary Principle in Radioactive Waste Management

The precautionary principle is one of the fundamental principles of modern environmental law. This principle emphasizes that when an activity has the potential to cause serious or irreversible damage, the absence of scientific certainty should not be used as a reason to postpone preventive measures. In the environmental context, prevention is considered more important than restoration because certain forms of environmental damage, particularly those related to hazardous and toxic substances, may persist for a long period. Wahyuni (2020) explains that the precautionary principle has a strategic position in hazardous and toxic waste management due to the dangerous, difficult-to-restore, and health-threatening characteristics of such waste. This principle becomes increasingly relevant in radioactive waste management because substances such as Cs-137 have a long half-life and may contaminate the environment for an extended period. Triana et al. (2023) also show that the precautionary principle not only functions at the preventive stage but can also be used in legal considerations when environmental pollution occurs. This indicates that the precautionary principle has developed from a mere policy guideline into a legal argument in the settlement of environmental disputes. In the case of radioactive contamination in exported frozen shrimp products, the precautionary principle should be applied from the stage of industrial raw material supervision, waste management, environmental monitoring within industrial areas, to food product testing prior to export. The application of this principle requires an early detection system, radiation screening of scrap metal, supervision of non-nuclear industrial activities, and inter-agency coordination among BAPETEN, the Ministry of Environment, the Ministry of Marine Affairs and Fisheries, the National Agency of Drug and Food Control, and customs authorities. If preventive supervision is not carried out effectively, the risk of radioactive pollution may spread to other sectors, including the food and fisheries sectors.

2.3. Radioactive Waste as High-Risk Hazardous and Toxic Waste

Radioactive waste has specific characteristics because it contains radionuclides that emit ionizing radiation. In the context of environmental law, radioactive waste may be associated with hazardous and toxic waste because it has the potential to endanger human health, the environment, and the sustainability of economic activities. Ramadhan et al. (2023) state that radioactive waste management from the perspective of environmental law must be carried out strictly because such waste poses long-term risks and requires technical supervision that differs from ordinary industrial waste. Radioactive waste management in Indonesia is also regulated under the nuclear law regime, particularly Law Number 10 of 1997 concerning Nuclear Energy and Government Regulation Number 61 of 2013 concerning Radioactive Waste Management. These regulations indicate that radioactive waste management does not only involve storage, but also collection, classification, processing, transportation, storage, and disposal. Therefore, every industrial activity that has the potential to come into contact with radioactive substances must comply with radiation safety standards and the supervision of the competent authority. The issue of radioactive waste in non-nuclear industries has become increasingly important because radioactive sources may enter industrial activities through secondary raw materials such as scrap metal. Fathurrahman (2020) emphasizes that the supervision of radioactive waste in non-nuclear industries is an important part of pollution prevention because not all radioactive sources originate from formal nuclear facilities. In this context, metal smelting industries, scrap metal processing activities, and industrial estates that accommodate various types of business activities must be supervised more strictly because they may become entry points for undetected radioactive sources.

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2.4. Radioactive Contamination in Food Products and Risks to Consumers

Food products contaminated with radioactive substances pose serious risks because consumers are unable to identify contamination through direct observation. Radioactivity does not necessarily alter the shape, color, smell, or taste of food products. Therefore, consumer protection against high-risk food products depends heavily on the state's supervision system, food safety standards, and the obligation of business actors to ensure product safety before distribution. The World Health Organization (2020) explains that exposure to ionizing radiation may cause biological effects on the human body, particularly when exposure occurs repeatedly or over a long period. In the context of marine food, studies by Buesseler (2012) and Fisher et al. (2013) show that radionuclide contamination in marine ecosystems may affect food safety, risk perception, and the sustainability of fishery product trade. A recent study by Johansen et al. (2025) also indicates that radiation dose assessment through seafood consumption must take into account the contribution of both naturally occurring radionuclides and anthropogenic radionuclides, including Cs-137. Under Indonesian consumer protection law, Law Number 8 of 1999 provides a legal basis for consumers to obtain comfort, security, and safety in consuming goods and/or services. Hidayat (2023) states that consumer protection against high-risk food products should not only be viewed from the perspective of compensation after harm occurs, but also from the perspective of prevention through the supervision of food safety standards. Therefore, if exported frozen shrimp products are contaminated with Cs-137, the issue is not only related to the relationship between producers and consumers, but also concerns the state's obligation to ensure food safety and protect public health.

2.5. Cross-Sectoral Coordination in Environmental and Food Safety Supervision

Radioactive pollution in exported frozen shrimp products within an industrial estate demonstrates the cross-sectoral nature of the problem. The source of contamination may originate from metal industry activities, its impact may enter the fisheries sector, and its legal consequences may involve environmental law, nuclear law, consumer protection law, food law, and international trade law. Therefore, fragmented sectoral supervision has the potential to create legal gaps and weaken law enforcement. Putra (2021) explains that cross-sectoral coordination in environmental supervision is necessary because environmental pollution often involves more than one area of authority. If coordination among institutions does not operate effectively, supervision may overlap or, conversely, leave regulatory gaps. In the case of Cs-137 contamination in exported frozen shrimp products, inter-agency coordination is highly important because BAPETEN has technical authority over radioactive substances, the Ministry of Environment has authority over environmental restoration, the Ministry of Marine Affairs and Fisheries plays a role in supervising fishery products, the National Agency of Drug and Food Control performs food safety supervision, and trade and customs authorities supervise the movement of goods across borders. Cross-sectoral coordination is also related to the fulfillment of the principle of good environmental governance. Good environmental governance requires clear authority, data transparency, rapid response, accountability of business actors, and protection for affected communities. Without strong coordination, the existing legal framework risks remaining merely normative and ineffective in preventing pollution and providing real protection for victims.

2.6. Legal Protection for Victims of Radioactive Pollution

Victims of radioactive pollution are not limited to final consumers who consume the product, but may also include workers, communities surrounding the industrial area, other business actors who suffer economic losses, and the state as the party that initially bears the costs of restoration. Therefore, legal protection for victims must be understood broadly through both preventive and repressive approaches. Preventive protection is carried out through licensing supervision, radiation testing, food safety standards,

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export certification, environmental monitoring, and the obligation of business actors to conduct due diligence on raw materials and production processes. Repressive protection is carried out after pollution occurs through administrative sanctions, civil claims, strict liability, compensation claims, environmental restoration, and criminal sanctions when legal violations are found. From the perspective of environmental law, victim protection becomes more effective when strict liability is applied consistently. This is because victims of radioactive pollution generally face technical difficulties in proving the source of contamination, the mechanism through which radioactive substances spread, and the direct causal relationship between pollution and the losses suffered. Under strict liability, victims only need to prove the existence of a risky activity, the existence of pollution or a serious threat, and the existence of loss. This mechanism is more suitable for radioactive pollution cases than an ordinary unlawful act mechanism, which requires proof of fault.

2.7. Hypothesis Development

Based on the literature review above, this study does not develop quantitative hypotheses because it uses a normative legal research method. Therefore, hypothesis development in this study is more appropriately understood as the development of legal propositions or argumentative assumptions to be examined through the analysis of legal norms, legal principles, and concrete cases. These propositions are formulated to answer the research problems and strengthen the direction of the analysis. The first proposition concerns environmental legal liability for radioactive pollution. Cs-137 contamination in exported frozen shrimp products indicates a serious risk that is cross-media and cross-sectoral in nature. Because radioactive substances are hazardous substances that may contaminate the environment and the food chain, legal liability for polluters should not be based solely on proof of fault, but also on strict liability and the polluter pays principle. Accordingly, business actors whose activities or negligence cause radioactive pollution may be required to provide compensation and conduct environmental restoration even when fault has not been proven in the conventional sense.

H1 : Environmental legal liability for Cs-137 radioactive contamination in exported frozen shrimp products in the Cikande Industrial Area is more appropriately based on the principles of strict liability and the polluter pays principle than on the ordinary unlawful act mechanism.

The second proposition concerns the function of the precautionary principle in the supervision of radioactive waste and food safety. Radioactive risk has characteristics that are not always directly identifiable and may cause long-term impacts. Therefore, the precautionary principle must be applied from the stages of licensing, raw material supervision, environmental monitoring, product testing, to the issuance of export certificates. If the precautionary principle is not consistently applied, radioactive pollution may enter the food supply chain and cause losses to consumers, workers, communities, and other business actors.

H2 : Weak implementation of the precautionary principle in the supervision of radioactive waste and the food supply chain increases the risk of Cs-137 contamination in exported frozen shrimp products.

The third proposition concerns inter-agency coordination. Radioactive contamination in exported frozen shrimp products cannot be addressed by a single institution because the issue involves environmental law, nuclear law, food law, consumer protection law, and international trade law. Weak coordination among institutions may lead to delayed detection, weak tracing of pollution sources, and suboptimal victim recovery. Therefore, effective legal protection requires integrated, preventive, and responsive coordination among BAPETEN, the Ministry of Environment, the Ministry of Marine Affairs and Fisheries, the National Agency of Drug and Food Control, and trade and customs authorities.

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H3 : The effectiveness of legal protection for victims of radioactive contamination in exported frozen shrimp products depends on integrated, preventive, and responsive cross-agency coordination.

The fourth proposition concerns victim protection. Victims of radioactive pollution include not only consumers, but also workers, surrounding communities, affected business actors, and the state as the party that conducts initial restoration. Therefore, legal protection must include both preventive and repressive mechanisms. Preventive protection is realized through supervision and testing, while repressive protection is realized through compensation, environmental restoration, administrative sanctions, and criminal sanctions. Without a combination of these two forms of protection, victims' rights to a good and healthy environment and to food safety cannot be optimally fulfilled.

H4 : Legal protection for victims of radioactive pollution in exported frozen shrimp products must be carried out through a combination of preventive and repressive protection in order to ensure victim recovery, food safety, and environmental sustainability.

III. Research Method

This study employs normative legal research or doctrinal legal research. Normative legal research is used because the focus of this study lies in the analysis of legal norms, legal principles, and legal doctrines related to environmental legal liability for radioactive contamination in exported frozen shrimp products in the Cikande Industrial Area. In normative legal research, law is understood as a system of norms that includes statutory regulations, legal principles, legal doctrines, and court decisions or legal cases relevant to the issues examined (Benuf & Azhar, 2020; Hutchinson & Duncan, 2012). Therefore, this study is not intended to empirically examine field data, but rather to analyze the consistency, adequacy, and effectiveness of legal regulations in providing a basis for liability and legal protection for victims of radioactive pollution. The approaches used in this study consist of the statutory approach, conceptual approach, and case approach. The statutory approach is used to examine various regulations related to environmental protection, hazardous and toxic waste management, radioactive substance supervision, food safety, and consumer protection. The regulations analyzed include Law Number 32 of 2009 concerning Environmental Protection and Management, as amended by Law Number 6 of 2023; Law Number 8 of 1999 concerning Consumer Protection; Law Number 10 of 1997 concerning Nuclear Energy, as amended by Law Number 6 of 2023; Law Number 18 of 2012 concerning Food; Government Regulation Number 61 of 2013 concerning Radioactive Waste Management; and technical regulations related to radiation safety, radioactive waste management, and food safety standards. The conceptual approach is used to analyze legal concepts and principles that form the basis of environmental legal liability, such as the precautionary principle, prevention principle, polluter pays principle, strict liability, state responsibility, and consumer protection. This approach is necessary because the case of Cesium-137 (Cs-137) contamination in exported frozen shrimp products is not only related to administrative violations or technical food safety issues, but also concerns the construction of legal liability for environmental risks that are cross-sectoral and cross-media in nature.

Through the conceptual approach, this study explains the legal arguments concerning the parties responsible, the forms of liability that may be applied, and the mechanisms of legal protection that may be provided to consumers, workers, surrounding communities, and affected business actors. The case approach is used in a limited manner to examine the incident of Cs-137 radioactive contamination in exported frozen shrimp products linked to the Cikande Industrial Area. This approach is not intended as empirical field research, but rather as an analytical instrument to position a concrete event as the basis for testing applicable legal norms. Through this approach, the study examines how norms of environmental law, nuclear law, food law, and consumer protection law can be used to assess the liability of business actors and the state's obligations in supervising and restoring damage caused by radioactive pollution. The legal materials used in this study consist of primary, secondary, and tertiary legal materials. Primary legal materials include relevant

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statutory regulations, such as the 1945 Constitution of the Republic of Indonesia, Law Number 32 of 2009 concerning Environmental Protection and Management, Law Number 8 of 1999 concerning Consumer Protection, Law Number 10 of 1997 concerning Nuclear Energy, Law Number 18 of 2012 concerning Food, Government Regulation Number 61 of 2013 concerning Radioactive Waste Management, and technical regulations issued by relevant institutions, particularly the Nuclear Energy Regulatory Agency. Secondary legal materials include legal books, national and international journal articles, research findings, scientific reports, and institutional documents relevant to radioactive pollution, food safety, and environmental protection. Tertiary legal materials include legal dictionaries, legal encyclopedias, regulatory indexes, and other supporting sources used to clarify the legal terms and concepts employed in this study. The technique for collecting legal materials is conducted through library research by tracing statutory regulations, legal literature, reputable journal articles, official institutional reports, and relevant legal documents.

The collection of legal materials is carried out selectively by considering relevance, source authority, currency, and direct connection to the issue of radioactive contamination in exported food products. Primary legal sources are obtained from official statutory regulation databases, while secondary legal materials are obtained from academic books, scientific journals, and institutional publications that can be academically accounted for. The technique for analyzing legal materials is qualitative, using deductive reasoning. The analysis begins with general norms governing environmental protection, hazardous and toxic waste management, supervision of radioactive substances, and consumer protection, and then applies them to the case of Cs-137 contamination in exported frozen shrimp products in the Cikande Industrial Area. The analysis is carried out through legal interpretation, norm systematization, regulatory synchronization, and assessment of the relevance of environmental law principles in determining forms of legal liability. Through this technique, the study seeks to answer whether the existing legal framework is adequate to impose liability on polluters and how legal protection for victims can be implemented both preventively and repressively. This study is limited to a normative analysis of environmental legal liability and legal protection for victims of radioactive pollution. Therefore, this study does not conduct laboratory measurements, field interviews, or empirical testing of radiation exposure levels. Data concerning the contamination incident are used as legal context to analyze the application of applicable legal norms and principles. Accordingly, this study is expected to provide a systematic legal argument for strengthening radioactive waste supervision, applying the principle of strict liability, and providing legal protection for consumers and affected communities.

IV. Result and Discussion

4.1. Analysis Result

a. The Character of Cs-137 Contamination as an Environmental Law and Food Safety Issue

The results of this study indicate that radioactive contamination of Cesium-137 (Cs-137) in exported frozen shrimp products in the Cikande Industrial Area cannot be understood merely as a technical food safety issue, but also as an environmental law issue. The contamination demonstrates an intersection between non-nuclear industrial activities, hazardous and toxic waste management, supervision of radioactive substances, consumer protection, and the sustainability of export trade. Cs-137 is a radionuclide that poses long-term risks because it can emit radiation and persist in the environment for an extended period. In the food context, this risk becomes more serious because radioactivity cannot be identified visually through the color, smell, taste, or physical appearance of a product. Venturi (2021) explains that exposure to radioactive cesium has biological and health implications when it enters the body through the environment or food. Therefore, Cs-137 contamination in exported frozen shrimp products must be treated as a serious risk requiring supervision based on the precautionary principle. Within the framework of Indonesian environmental law, Cs-137 contamination may be classified as pollution when there is an introduction of substances, energy, or other components into the environment that exceeds environmental quality standards or creates a serious threat to the environment and human health. Therefore, radioactive contamination in exported frozen shrimp

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products must be analyzed through a cross-regime legal approach, namely environmental law, nuclear law, food law, consumer protection law, and international trade law.

b. Mapping the Relevant Legal Framework

The findings of this study indicate that Indonesia has several legal instruments that provide the basis for assessing legal liability arising from radioactive contamination. The primary legal instrument in the field of environmental law is Law Number 32 of 2009 concerning Environmental Protection and Management. This law establishes fundamental principles, including state responsibility, the precautionary principle, the prevention principle, the polluter pays principle, and strict liability. In the field of nuclear law, Law Number 10 of 1997 concerning Nuclear Energy, as amended by Law Number 6 of 2023, provides the legal framework for regulating radiation safety and the supervision of radioactive materials. This responsibility is vested in the Nuclear Energy Regulatory Agency (BAPETEN). At the international level, this framework is consistent with the standards established by the International Atomic Energy Agency (IAEA), which emphasize the importance of a comprehensive legal framework, an effective institutional structure, and an independent regulatory authority to ensure radiation safety (International Atomic Energy Agency [IAEA], 2016). With respect to food safety and consumer protection, Law Number 18 of 2012 concerning Food, Law Number 8 of 1999 concerning Consumer Protection, and Minister of Health Regulation Number 1031/Menkes/PER/V/2011 concerning Maximum Limits of Radioactive Contamination in Food provide the legal basis for ensuring food safety and protecting consumers' rights to safe food. Consequently, the case of Cs-137 contamination in exported frozen shrimp products falls within the intersection of several interconnected legal regimes.

Table 1. Mapping of the Relevant Legal Framework for the Cs-137 Contamination Case in Exported Frozen Shrimp Products

Legal Regime	Legal Instrument	Regulatory Scope	Relevance to the Cs-137 Contamination Case
Environmental Law	Law Number 32 of 2009 concerning Environmental Protection and Management	Establishes the principles of state responsibility, the precautionary principle, the polluter pays principle, strict liability, and administrative, civil, and criminal sanctions.	Serves as the primary legal basis for environmental liability, pollution control, and environmental restoration.
Nuclear Law	Law Number 10 of 1997 concerning Nuclear Energy, as amended by Law Number 6 of 2023	Regulates the utilization of nuclear energy, radiation safety, and the protection of public health and the environment.	Provides the legal basis for BAPETEN's authority to supervise radioactive materials and ensure radiation safety.
Radiation Safety	Government Regulation Number 45 of 2023 and BAPETEN technical regulations on ionizing radiation safety and radioactive material security	Governs the control of radioactive sources, radiation safety, inspections, radioactive material security, and emergency response measures.	Serves as the technical framework for monitoring, preventing, and responding to radioactive contamination incidents.
Radioactive Waste Management	Government Regulation Number 61 of 2013 concerning Radioactive Waste Management	Regulates the management, storage, transportation, treatment,	Provides the legal basis for assessing obligations related to the management of

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		and disposal of radioactive waste.	materials or waste contaminated with Cs-137.
Food Law	Law Number 18 of 2012 concerning Food and Minister of Health Regulation Number 1031/Menkes/PER/V/2011	Establishes the obligations of the government and business actors to ensure food safety, including maximum permissible limits for radioactive contamination.	Provides the legal basis for food safety testing, regulatory oversight, and the control of contaminated food products.
Consumer Protection	Law Number 8 of 1999 concerning Consumer Protection	Guarantees consumers' rights to safety, security, accurate information, and compensation.	Serves as the legal basis for protecting consumers affected by contaminated or high-risk food products.

c. BAPETEN's Authority and the Need for Cross-Agency Coordination

The findings of this study indicate that BAPETEN plays a central role in regulating and supervising radiation safety and the security of radioactive materials. Its authority encompasses regulatory development, licensing, inspections, oversight of radiation sources, and the implementation of control measures to prevent radiation hazards. This regulatory framework is consistent with the standards established by the International Atomic Energy Agency (IAEA), which recognizes an independent regulatory authority as a fundamental component of the national radiation safety system (IAEA, 2016). However, the case of Cs-137 contamination in exported frozen shrimp products demonstrates that the supervision of radioactive materials cannot be carried out by BAPETEN alone. Once radioactive contamination affects exported food products, the matter also falls within the jurisdiction of the Ministry of Environment, the National Agency of Drug and Food Control (BPOM), the Ministry of Marine Affairs and Fisheries, customs authorities, law enforcement agencies, local governments, and industrial estate management authorities. BPOM (2025) reported that the government's response to the Cs-137 contamination case in Indonesian frozen shrimp involved coordinated action among multiple agencies because the incident concerned both food safety and public confidence in Indonesia's export products. These findings suggest that the principal challenge lies not in the absence of an adequate legal framework but rather in the fragmentation of institutional authority. Such fragmentation may result in delayed detection, inadequate information sharing, ineffective tracing of contamination sources, and slower recovery for affected parties. Therefore, effective supervision of radioactive contamination throughout the export food supply chain requires an integrated, permanent, and risk-based model of inter-agency coordination.

d. Construction of Environmental Legal Liability

The findings of this study indicate that legal liability for Cs-137 contamination may be established through three legal mechanisms: administrative, civil, and criminal liability. Administrative liability serves as an immediate regulatory response to halt hazardous activities, prevent the spread of pollution, and require environmental restoration. Administrative measures may include written warnings, government enforcement actions, temporary suspension of operations, suspension or revocation of permits, seizure of hazardous materials, and mandatory environmental restoration. Within the context of civil law, the principle of strict liability under Article 88 of Law Number 32 of 2009 provides the most appropriate legal basis for liability. According to Takdir Rahmadi (2020), strict liability plays a crucial role in environmental law because environmental pollution is often scientifically complex and difficult to establish through conventional fault-based liability. In cases involving radioactive contamination, victims typically encounter significant technical obstacles in proving the source of contamination, the mechanism of radioactive dispersion, and the causal

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relationship between the polluter's activities and the resulting damage. From the perspective of criminal law, liability may be imposed where intentional misconduct or negligence is established in the management of hazardous and toxic waste or radioactive waste, where actions result in violations of environmental quality standards, or where conduct poses a serious threat to human health and the environment. Nevertheless, criminal sanctions should not be regarded as the sole mechanism for resolving environmental disputes. In environmental cases, criminal law enforcement should operate alongside environmental restoration and compensation for affected parties.

e. Comparison Between Strict Liability and Fault-Based Tort Liability

The findings of this study indicate that cases involving radioactive contamination are more appropriately resolved under the principle of strict liability than through conventional fault-based tort claims. A tort claim under Article 1365 of the Indonesian Civil Code requires the claimant to establish the existence of an unlawful act, fault, damage, and a causal relationship between the defendant's conduct and the resulting harm. In cases of radioactive contamination, this burden of proof is particularly onerous because it requires sophisticated technical evidence, laboratory analysis, and comprehensive investigation of the contamination pathway. By contrast, strict liability shifts the emphasis from proving fault to demonstrating the existence of a hazardous activity, environmental pollution or a serious environmental threat, and resulting damage. Although strict liability does not eliminate the need for evidence, it substantially reduces the victim's evidentiary burden because proof of the business actor's negligence or intent is not required. Consequently, strict liability is a more appropriate legal mechanism for addressing environmental damage caused by hazardous and toxic substances, including radioactive contamination.

Table 2. Comparison Between Strict Liability and Fault-Based Tort Liability in Radioactive Contamination Cases

Aspect	Strict Liability under Article 88 of Law Number 32 of 2009	Fault-Based Tort Liability under Article 1365 of the Indonesian Civil Code
Legal Basis	Article 88 of Law Number 32 of 2009 concerning Environmental Protection and Management	Article 1365 of the Indonesian Civil Code
Nature of Liability	Objective and risk-based liability	Subjective and fault-based liability
Burden of Proof	The claimant must establish the existence of a hazardous activity, environmental pollution or a serious threat, and the resulting damage. Proof of fault is not required.	The claimant must establish an unlawful act, fault, damage, and a causal relationship between the defendant's conduct and the resulting harm.
Suitability for Radioactive Contamination Cases	Highly appropriate because radioactive contamination is scientifically complex, may spread across multiple environmental media, and is difficult to prove through fault-based evidence.	Less effective because victims often lack access to technical evidence, laboratory findings, and investigation results necessary to establish fault.
Primary Function	Strengthens environmental protection, victim compensation, and environmental restoration.	Primarily intended to resolve ordinary civil disputes based on fault.
Application to the Cikande Case	May serve as the principal basis for civil liability once the source of contamination has been identified.	May serve as a complementary legal basis where fault can be established through sufficient evidence.

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f. Legal Protection for Victims of Radioactive Contamination

The findings of this study indicate that victims of radioactive contamination should be understood in a broad sense. Victims include not only final consumers who may be exposed to contaminated frozen shrimp products but also workers within the industrial estate, surrounding communities, fishery business actors who suffer economic losses, and the government, which is often required to bear the initial costs of emergency response and environmental remediation. Miru and Yodo (2018) emphasize that consumer protection is founded on consumers' rights to safety, security, comfort, accurate information, and compensation for losses resulting from the use of goods and/or services. Legal protection for victims in the Cs-137 contamination case should be implemented through both preventive and repressive measures. Preventive protection aims to minimize the risk of radioactive exposure and prevent contaminated products from entering the food supply chain. Repressive protection, by contrast, seeks to restore the rights of affected parties through compensation, environmental restoration, and the imposition of legal sanctions on those responsible for the contamination.

Table 3. Forms of Legal Protection for Victims of Cs-137 Radioactive Contamination

Form of Protection	Legal Instrument or Measure	Protected Parties	Objective
Preventive Protection	Licensing oversight, radiation monitoring, food product testing, export certification, product traceability, and early warning systems	Consumers, workers, surrounding communities, and food business operators	To prevent environmental contamination, radioactive exposure, and the distribution of contaminated food products.
Administrative Repressive Protection	Written warnings, government enforcement measures, suspension of operations, suspension or revocation of permits, and mandatory environmental restoration	Affected communities and the environment	To halt regulatory violations, enforce compliance, and accelerate environmental recovery.
Civil Repressive Protection	Compensation claims, strict liability, the polluter pays principle, and environmental restoration	Consumers, workers, surrounding communities, affected business operators, and the government	To compensate for health, economic, and environmental losses while restoring the rights of affected parties.
Criminal Repressive Protection	Enforcement of environmental, nuclear, and consumer protection laws where the required elements of criminal liability are established	The public interest and victims	To impose criminal sanctions, create a deterrent effect, and prevent similar violations in the future.
Health and Social Recovery	Medical examinations, healthcare services, temporary relocation where necessary, radiation exposure monitoring, and public disclosure of information	Workers and surrounding communities	To mitigate the health and social impacts resulting from radioactive contamination.

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4.2. Discussion

a. Chronology of Cs-137 Contamination as a Cross-Sectoral Environmental Law Issue

The case of Cesium-137 (Cs-137) contamination in Indonesian exported frozen shrimp products associated with the Cikande Industrial Area should first be understood within its chronological and legal context. The issue emerged when radioactive contamination was detected in frozen shrimp products intended for export. Although the contaminated products were fishery commodities, the potential source of contamination did not necessarily originate from shrimp farming or fishery processing activities. Rather, the contamination was allegedly linked to broader industrial activities within or surrounding the Cikande Industrial Area, particularly those involving scrap metal, recycled industrial materials, used equipment, or other materials contaminated by radioactive sources. This chronology demonstrates that Cs-137 contamination cannot be regarded merely as a technical food safety issue. Instead, it constitutes a cross-sectoral environmental law issue because radioactive substances may disperse through environmental media such as air, dust, soil, wastewater, solid waste, or industrial production facilities before ultimately contaminating food products within the supply chain. In this context, exported frozen shrimp products represent the endpoint of a broader chain of environmental risk. Consequently, the contamination case extends beyond food safety and encompasses industrial estate governance, radioactive waste supervision, hazardous and toxic waste management, consumer protection, and the international reputation of Indonesia's fishery exports. Previous studies on radiocesium contamination in marine food products support the view that radioactive contamination requires continuous monitoring and preventive regulatory oversight.

Buesseler (2012) explains that radiocesium contamination following the Fukushima nuclear accident raised significant concerns regarding seafood safety, environmental monitoring systems, and public confidence in fishery products. Similarly, Fisher et al. (2013) demonstrate that risk assessments of radionuclides in marine ecosystems must consider exposure pathways affecting both marine organisms and seafood consumers. These studies are particularly relevant to the Cikande case because they indicate that Cs-137 contamination should not be assessed solely at the level of the final product but also throughout the environmental pathways and supply chain through which radioactive substances may enter food products. Furthermore, Lin et al. (2024), through a decade-long observational study of Fukushima-derived radiocesium, demonstrate that radionuclides may persist and undergo dynamic changes within the marine environment over extended periods. Applied to the Cikande case, this finding reinforces the argument that monitoring of Cs-137 should not be temporary, incidental, or merely reactive after contamination has been detected. Instead, regulatory oversight should be continuous, particularly in industrial areas where activities may involve unauthorized or uncontrolled radioactive sources. Accordingly, an industrial estate should be viewed as an integrated risk ecosystem in which the activities of one business operator may generate adverse consequences for other businesses, workers, surrounding communities, consumers, and exported products.

b. Relevant Legal Framework and Potential Legal Violations

Following the reconstruction of the chronology, the next step is to identify the applicable legal framework and the potential legal violations arising from the Cs-137 contamination case. This case falls within several interconnected legal regimes, including environmental law, nuclear law, food law, consumer protection law, and international trade law. The principal legal basis is Law Number 32 of 2009 concerning Environmental Protection and Management, which establishes the principles of state responsibility, the precautionary principle, the polluter pays principle, and strict liability. This legislation is particularly relevant because radioactive contamination may constitute environmental pollution or pose a serious threat to both the environment and public health. In addition, Law Number 10 of 1997 concerning Nuclear Energy, as amended by Law Number 6 of 2023, provides the legal framework governing the utilization of nuclear energy, the control of radioactive materials, and radiation safety. This legislation forms the basis of the authority exercised by the Nuclear Energy Regulatory Agency (BAPETEN) in supervising radioactive sources and ensuring that radioactive materials are used, stored, transported, and disposed of in accordance with

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applicable legal requirements. Government Regulation Number 61 of 2013 concerning Radioactive Waste Management and Government Regulation Number 45 of 2023 concerning Ionizing Radiation Safety and Radioactive Material Security are likewise relevant, as they establish technical requirements for the control, management, and safe handling of radioactive materials. From the perspective of food law, Law Number 18 of 2012 concerning Food requires that all food products distributed or traded satisfy established standards of safety, quality, and nutritional value. In the context of exported frozen shrimp products, food safety supervision is particularly important because radioactive contamination may endanger consumers and undermine international confidence in Indonesia's fishery exports. Furthermore, Law Number 8 of 1999 concerning Consumer Protection guarantees consumers' rights to safety, security, comfort, accurate information, and compensation for losses arising from the use or consumption of goods and services. Based on these legal frameworks, several potential legal violations may be identified in the Cs-137 contamination case. These include inadequate supervision of radioactive sources, insufficient radiation screening of industrial raw materials, improper management of radioactive or hazardous waste, failure to prevent environmental contamination, inadequate food safety testing prior to export, and insufficient protection of consumers, workers, and surrounding communities. Consequently, the legal issues extend beyond determining whether contamination occurred. They also require an assessment of whether the responsible parties fulfilled their preventive, supervisory, and remedial obligations under the applicable legal framework.

c. Fulfillment of the Elements of Environmental Legal Liability

The third stage of the analysis examines whether the legal elements required to establish environmental liability are satisfied. Under environmental law, liability does not depend solely on proof of subjective fault, particularly where activities involve hazardous substances, hazardous waste, radioactive materials, or pose a serious threat to the environment. Instead, the relevant elements include the existence of a hazardous activity, the occurrence of environmental pollution or a serious environmental threat, the existence of damage or losses suffered by affected parties, and a causal relationship between the source of contamination and the resulting harm. In the Cs-137 contamination case, the first element is the existence of a hazardous activity. Industrial operations involving scrap metal, recycled materials, or other materials that may contain radioactive sources may be classified as high-risk activities when they are not accompanied by adequate radiation screening and appropriate safety controls. The second element is the occurrence of environmental pollution or a serious environmental threat. Cs-137 is a radioactive substance that can persist in the environment and contaminate food products through environmental media or industrial production facilities. This characteristic makes Cs-137 contamination a significant threat to environmental quality, public health, and food safety. The third element is the existence of damage or losses. Such losses may be suffered by a wide range of affected parties, including consumers who may be exposed to contaminated products, workers within the affected industrial area, surrounding communities located near the source of contamination, fishery business operators whose products are rejected or lose market confidence, and the government, which may initially bear the costs of emergency response and environmental remediation. The fourth element is causation, namely the existence of a causal relationship between the source of contamination and the resulting damage or risk. Although establishing causation in cases of radioactive contamination is scientifically and technically complex, it may be demonstrated through environmental investigations, radiation testing, environmental monitoring, product traceability, and the findings of competent regulatory authorities.

Given the complexity of proving liability in cases of radioactive contamination, the principle of strict liability provides a more appropriate legal mechanism than conventional fault-based tort liability. Under Article 1365 of the Indonesian Civil Code, claimants must establish the existence of an unlawful act, fault, damage, and a causal relationship between the defendant's conduct and the resulting harm. In radioactive contamination cases, this burden of proof is particularly difficult because it involves complex scientific issues, including contamination pathways, radiation levels, environmental dispersion, and exposure mechanisms. By contrast, Article 88 of Law Number 32 of 2009 establishes a strict liability regime that focuses on the existence

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of a hazardous activity, environmental pollution or a serious environmental threat, and the resulting damage, without requiring victims to prove the subjective fault or negligence of the business operator. Nevertheless, strict liability does not imply that a business operator is automatically held liable without due legal process. Liability must still be established by demonstrating that the activity involved hazardous substances, hazardous waste, or a serious environmental threat and that environmental pollution or damage actually occurred. However, the doctrine substantially reduces the evidentiary burden imposed on victims because they are not required to prove intent or negligence in the conventional sense. Accordingly, strict liability is consistent with the principle of due process of law while providing stronger legal protection for victims of environmental pollution.

d. Strict Liability and the Polluter Pays Principle

The principle of strict liability should be interpreted in conjunction with the polluter pays principle. Under this principle, the party responsible for environmental pollution is required to bear the costs of pollution prevention, mitigation, environmental restoration, and compensation for affected parties. In cases involving radioactive contamination, the application of this principle is particularly important because the financial costs associated with contamination management can be substantial. These costs may include radiation monitoring, identification of contamination sources, removal, transportation, and secure storage of contaminated materials, decontamination of industrial facilities, laboratory testing, medical examinations, temporary relocation of affected populations where necessary, environmental restoration, and compensation for economic losses. If these costs are borne solely by the government or society, the financial burden of environmental damage is unfairly shifted from the polluter to the public. Such an outcome is inconsistent with the principle of environmental justice. Although the government may undertake immediate emergency measures to protect public health and prevent further environmental harm, the ultimate responsibility for environmental restoration and compensation should remain with the party proven to have caused the contamination. Accordingly, the polluter pays principle ensures that the costs arising from environmental damage remain a legal responsibility of the polluter rather than becoming a public burden. In the Cikande case, if it is established that particular industrial activities caused the release and dispersion of Cs-137 into the environment, resulting in the contamination of exported frozen shrimp products, the responsible business operator may be required to bear the costs of environmental decontamination, environmental restoration, victim recovery, laboratory testing, health monitoring, and compensation for affected fishery business operators. This approach reinforces the corrective function of environmental law by ensuring that legal liability is directed not only toward imposing sanctions but also toward restoring environmental quality and compensating those who have suffered harm.

e. Administrative, Civil, and Criminal Sanctions

After the elements of liability are analyzed, the discussion must be directed toward the forms of sanctions that may be imposed. In environmental law, the resolution of radioactive contamination cannot rely on a single form of liability. Administrative, civil, and criminal sanctions may operate simultaneously or in layers according to the type of violation, the degree of risk, and the consequences caused. Administrative sanctions function as rapid legal instruments to stop violations and prevent the expansion of contamination. These sanctions may include written warnings, government coercive measures, temporary suspension of activities, freezing or revocation of permits, seizure of hazardous materials, and orders to conduct environmental restoration. Administrative sanctions are essential in radioactive contamination cases because delayed action may increase exposure risks and prolong harm to workers, surrounding communities, and business actors. Civil liability functions to provide compensation and environmental restoration. In this case, civil liability may be based on strict liability and the polluter pays principle. Compensation may cover health losses, economic losses, product rejection, business interruption, reputational damage, testing costs, and environmental recovery costs. Civil liability is important because environmental law does not only aim to

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identify the offender, but also to restore the position of victims and repair the damaged environment. Criminal sanctions may be applied if the contamination results from intentional conduct, gross negligence, unlawful management of hazardous or radioactive materials, violation of radiation safety requirements, or actions that create a serious threat to public health and the environment. Criminal enforcement is necessary to create deterrence, especially when the violation reflects serious disregard for safety obligations. However, criminal sanctions should not replace the obligation to restore the environment and compensate victims. In environmental law, punishment without restoration is insufficient, while restoration without sanctions may fail to prevent recurrence.

f. Position of Fishery Business Actors and Due Diligence Obligations

The position of fishery business actors in the Cs-137 case must be assessed proportionally. If the contamination is proven to originate from other industrial activities within or around the industrial area, and not from the internal production process of the fishery business actor, then the fishery business actor may be positioned as an affected party or economic victim. Losses suffered by fishery business actors may include export rejection, additional testing costs, production suspension, reputational damage, and loss of trust in international markets. However, being an affected party does not eliminate the due diligence obligations of food business actors. Under food law and consumer protection law, business actors are required to ensure that products distributed or exported are safe for consumption. This obligation includes product testing, raw material traceability, production process control, storage safety, packaging safety, and compliance with food safety standards. Therefore, the responsibility of the primary polluter must be distinguished from the responsibility of food business actors. The primary polluter is responsible for the source and spread of contamination. Meanwhile, fishery business actors are responsible for ensuring that their products meet food safety requirements before distribution or export. If fishery business actors have conducted reasonable testing, supervision, and traceability, their position is more appropriately classified as economic victims. Conversely, if negligence is found in product testing, quality control, or traceability, limited liability may still be imposed according to the degree of negligence.

g. State Responsibility in Supervision and Recovery

The state has a constitutional responsibility to guarantee the right of citizens to a good and healthy environment. Article 28H paragraph (1) of the 1945 Constitution of the Republic of Indonesia provides the constitutional basis for environmental protection. Law Number 32 of 2009 also affirms state responsibility as one of the principles of environmental protection and management. Therefore, in radioactive contamination cases, the state must act as regulator, supervisor, law enforcer, and guarantor of initial public protection. State responsibility in the Cs-137 case includes prevention, supervision, emergency response, information disclosure, initial recovery, and victim protection. The state is not automatically positioned as the polluter. However, the state may be considered to have failed in its supervisory function if serious negligence occurs in preventing the entry of unauthorized radioactive materials, supervising industrial estates, integrating inter-agency data, or providing accurate and timely information to the public. Initial recovery by the state must not be interpreted as a transfer of liability from the polluter to the government. The government may take emergency measures to protect public health and prevent the spread of contamination, but the costs of restoration and compensation may still be claimed from the party proven to have caused the pollution. This approach ensures that the state fulfills its public protection function while maintaining the legal responsibility of the polluter.

h. Preventive and Repressive Legal Protection for Victims

Legal protection for victims of radioactive pollution must be implemented through both preventive and repressive mechanisms. Preventive protection aims to prevent exposure and stop hazardous products from entering the market or export chain. Its forms include licensing supervision, radiation screening, industrial estate monitoring, environmental testing, food product testing, export certification, product

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traceability, and early warning systems. Repressive protection is implemented after pollution occurs. It includes health examinations, medical treatment, temporary relocation, compensation, environmental restoration, administrative sanctions, civil claims, criminal enforcement, and access to legal assistance. In radioactive contamination cases, repressive protection must be carried out promptly because the impact of exposure may create health uncertainty, social anxiety, and continuing economic losses. Victims in this case should be understood broadly. They are not limited to final consumers, but also include workers, surrounding communities, fishery business actors, and the state as the party that may initially bear emergency response costs. Therefore, victim protection cannot consist merely of imposing sanctions on the perpetrator. Victims must also obtain access to information, health services, complaint mechanisms, compensation procedures, and guarantees of environmental recovery.

I. Strengthening the Governance of Radioactive Supervision and Export Food Safety

The Cs-137 contamination case demonstrates the need to strengthen the governance of radioactive supervision and export food safety. Supervision should not be conducted only at the final stage before export. It must begin from the entry of industrial raw materials, radiation screening of scrap metal and recycled materials, industrial estate monitoring, environmental testing, production process control, storage, distribution, and export certification. Governance strengthening can be carried out through several measures. First, radiation screening of scrap metal, recycled materials, and high-risk industrial raw materials must be tightened. Second, industrial estates that host high-risk activities must establish integrated environmental and radiation monitoring systems. Third, supervisory data from BAPETEN, the Ministry of Environment, BPOM, the Ministry of Marine Affairs and Fisheries, customs authorities, local governments, and industrial estate managers must be integrated. Fourth, export-oriented food business actors operating in or near high-risk areas should be required to implement stricter traceability and product testing systems. Thus, the resolution of the Cs-137 contamination case should not be limited to enforcement against one business actor. This case should become a momentum to reform the supervision system for radioactive waste, food safety, and industrial estate governance. Without systemic reform, similar risks may recur and may again harm consumers, workers, surrounding communities, business actors, the environment, and Indonesia's export reputation. Based on the above discussion, Cs-137 contamination in exported frozen shrimp products must be positioned as a complex environmental law issue. The analysis must proceed sequentially from the chronology of the case, identification of relevant legal norms, assessment of the fulfillment of liability elements, and determination of possible sanctions and victim protection. This structure shows that radioactive contamination is not only a matter of food safety, but also a matter of environmental legal liability involving business actors, the state, consumers, workers, surrounding communities, and affected fishery business actors.

V. Conclusion

Based on the findings of this study, the contamination of exported frozen shrimp products with Cesium-137 (Cs-137) in the Cikande Industrial Area constitutes a cross-sectoral environmental law issue. The case is not limited to food safety concerns but also involves the management of hazardous and toxic waste, radioactive waste, radiation safety oversight, consumer protection, industrial estate governance, and the sustainability of Indonesia's fishery exports. From a normative perspective, Indonesia has established a comprehensive legal framework through Law Number 32 of 2009 concerning Environmental Protection and Management, Law Number 10 of 1997 concerning Nuclear Energy, Law Number 18 of 2012 concerning Food, and Law Number 8 of 1999 concerning Consumer Protection. Nevertheless, the Cs-137 contamination case reveals a persistent gap between the existing legal framework and its implementation, particularly with respect to early detection, inter-agency coordination, oversight of high-risk industrial raw materials, and regulatory control of exported food products. Environmental legal liability in this case is most appropriately established through the principles of strict liability and the polluter pays principle. Article 88 of Law Number 32 of 2009 provides the legal basis for imposing liability on business operators whose activities involve the

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use, generation, or management of hazardous and toxic substances or hazardous and toxic waste, or whose activities pose a serious threat to the environment, without requiring prior proof of fault. This principle is particularly appropriate because radioactive contamination is scientifically complex, may spread through multiple environmental media, and is difficult to address under conventional fault-based liability. Furthermore, the polluter pays principle requires that the costs of mitigation, decontamination, environmental restoration, medical examinations, relocation, and economic compensation be borne by the party responsible for the pollution rather than by the government or the public. Legal protection for victims of radioactive contamination should be interpreted broadly. Victims include not only final consumers but also workers within the industrial estate, surrounding communities, fishery business operators that suffer economic losses, and the government, which frequently bears the initial costs of emergency response and environmental remediation. Such protection should be implemented through both preventive and repressive legal measures.

Preventive protection includes licensing oversight, radiation screening, food product testing, export certification, product traceability, and early warning systems. Repressive protection includes administrative sanctions, compensation claims, the application of strict liability, environmental restoration, medical examinations, compensation, relocation where necessary, and criminal law enforcement when the legal elements of criminal liability are satisfied. Accordingly, legal protection for victims of radioactive contamination should not be limited to post-incident responses but should be supported by a comprehensive, integrated, and sustainable system of risk prevention. Based on these findings, the government should strengthen the regulatory framework governing the supervision of radioactivity in exported fishery products. Such regulations should clearly establish Cs-137 testing standards, require mandatory testing by accredited laboratories before the issuance of export health certificates, strengthen product traceability systems, and provide clear administrative, civil, and criminal sanctions for business operators that violate food safety and radiation safety requirements. The government should also strengthen oversight of high-risk industrial raw materials, particularly scrap metal and recycled materials that may serve as sources of unauthorized radioactive substances. Furthermore, BAPETEN, BPOM, the Ministry of Marine Affairs and Fisheries, the Ministry of Environment, customs authorities, local governments, and industrial estate management authorities should establish a permanent and integrated inter-agency coordination mechanism. Such coordination may include the establishment of a permanent task force responsible for supervising radioactive contamination in food supply chains and industrial estates, the development of inter-agency memoranda of understanding, and the implementation of an integrated information system that enables real-time data sharing. These measures are essential to ensure that early detection, source identification, product testing, and victim recovery are carried out efficiently and in a coordinated manner.

Business operators within industrial estates, particularly those engaged in metal smelting, recycled material processing, or other activities involving potential exposure to radioactive substances, should be required to conduct periodic radiation screening. Such monitoring should include inspections of incoming raw materials, workplace environmental monitoring, testing of production facilities, and regular reporting to the relevant regulatory authorities. Likewise, fishery export companies should strengthen their due diligence practices by implementing periodic product testing, comprehensive raw material traceability, rigorous quality control procedures, and verifiable food safety documentation. In addition, communities and consumers should be encouraged to increase their awareness of food safety by paying close attention to product labels, distribution permits, food safety certifications, and official information issued by government authorities. Communities living or working in the vicinity of high-risk industrial areas should also have access to transparent information regarding environmental safety conditions, radiation monitoring results, health examination procedures, and complaint mechanisms available in the event of harm. Public protection should extend beyond information disclosure and include accessible healthcare services, legal assistance, and effective compensation mechanisms. Future research should focus on empirical assessments of the effectiveness of inter-agency coordination in supervising radioactive contamination within food supply chains and industrial estates. Further studies may also examine models of corporate environmental liability in cases

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of radioactive contamination, compensation mechanisms for affected parties, and comparative analyses of radioactive food safety regulations between Indonesia and major export destination countries. Such research would contribute to strengthening the academic foundation for regulatory reform and improving the governance of food safety and environmental protection within Indonesia's export sector.

References

Associated Press. (2025). Radioactive metal at an Indonesia industrial site may be linked to shrimp recall. Associated Press.

Badan Pengawas Obat dan Makanan. (2025, September 12). BPOM responds with the government to the Cs-137 case in Indonesian frozen shrimp. Badan Pengawas Obat dan Makanan.

Badan Pengawas Tenaga Nuklir. (2025, September 26). Supervision of the handling of Cesium-137 (Cs-137) contamination in the Modern Cikande Industrial Area [Press release]. Badan Pengawas Tenaga Nuklir.

Benuf, K., & Azhar, M. (2020). Legal research methodology as an instrument for addressing contemporary legal issues. Gema Keadilan, 7(1), 20–33. https://doi.org/10.14710/gk.2020.7504

Buesseler, K. O. (2012). Fishing for answers off Fukushima. Science, 338(6106), 480–482. https://doi.org/10.1126/science.1228250

Cahyani, F. A., & Anditya, A. W. (2024). Implementation of precautionary principles in environmental impact assessment (EIA) in Indonesia. Unifikasi: Jurnal Ilmu Hukum, 11(1), 40–45. https://doi.org/10.25134/unifikasi.v11i01.765

Detik.com. (2025, December 4). Police name the boss of PT PMT as a suspect in the Cs-137 radioactive case in Cikande. Detik.com.

Fathurrahman, S. A. (2020). Supervision of radioactive waste in non-nuclear industries. Indonesian Journal of Environmental Law.

Fisher, N. S., Beaugelin-Seiller, K., Hinton, T. G., Baumann, Z., Madigan, D. J., & Garnier-Laplace, J. (2013). Evaluation of radiation doses and associated risk from the Fukushima nuclear accident to marine biota and human consumers of seafood. Proceedings of the National Academy of Sciences, 110(26), 10670–10675. https://doi.org/10.1073/pnas.1221834110

Food and Agriculture Organization. (2019). Food safety and nuclear contaminants. Food and Agriculture Organization.

Hidayat, R. (2023). Consumer protection against high-risk food products under the Consumer Protection Law. Journal of Critical Legal Studies.

Hutchinson, T., & Duncan, N. (2012). Defining and describing what we do: Doctrinal legal research. Deakin Law Review, 17(1), 83–119.

Indonesia. (1997). Law Number 10 of 1997 concerning Nuclear Energy.

Indonesia. (1999). Law Number 8 of 1999 concerning Consumer Protection.

Indonesia. (2009a). Government Regulation Number 46 of 2009 concerning the Limitation of Liability for Nuclear Damage.

Indonesia. (2009b). Law Number 32 of 2009 concerning Environmental Protection and Management.

Indonesia. (2011). Minister of Health Regulation Number 1031/Menkes/PER/V/2011 concerning Maximum Limits of Radioactive Contamination in Food.

Indonesia. (2012a). Presidential Regulation Number 74 of 2012 concerning Liability for Nuclear Damage.

Indonesia. (2012b). Law Number 18 of 2012 concerning Food.

Indonesia. (2013a). Regulation of the Head of the Nuclear Energy Regulatory Agency Number 4 of 2013 concerning Radiation Protection and Safety in the Utilization of Nuclear Energy.

Indonesia. (2013b). Government Regulation Number 61 of 2013 concerning Radioactive Waste Management.

Indonesia. (2020). Law Number 11 of 2020 concerning Job Creation.

Indonesia. (2023a). Government Regulation Number 45 of 2023 concerning Ionizing Radiation Safety and Radioactive Substance Security.

2026. The Author(s). This open-access article is distributed under a Creative Commons Attribution (CC-BY-SA) 4.0 license.

ISSN [Online]: 2808-2923

Indonesia. (2023b). Law Number 6 of 2023 concerning the Stipulation of Government Regulation in Lieu of Law Number 2 of 2022 concerning Job Creation into Law.

International Atomic Energy Agency. (2016). Governmental, legal and regulatory framework for safety: General Safety Requirements No. GSR Part 1 (Rev. 1). International Atomic Energy Agency.

International Atomic Energy Agency. (2019). Radiological contamination of food and the environment. International Atomic Energy Agency.

Johansen, M. P., Ruedig, E., Tagami, K., Uchida, S., Higley, K. A., Beresford, N. A., & Brown, J. E. (2015). Radiological dose rates to marine fish from the Fukushima Daiichi accident: The first three years across the North Pacific. Environmental Science & Technology, 49(3), 1277–1285. https://doi.org/10.1021/es505064d

Kementerian Lingkungan Hidup. (2025, September 30). Press release on the handling of Cesium-137 contamination in the Cikande Industrial Area. Kementerian Lingkungan Hidup.

Lin, W., Tsumune, D., Tateda, Y., Aoyama, M., & Tsubono, T. (2024). Deciphering decadal observation of Fukushima-derived radiocesium in marine fish and seawater. Frontiers in Marine Science, 11, Article 1382229. https://doi.org/10.3389/fmars.2024.1382229

Makarim, N. (2020). Strict liability in consumer law. Jurnal Hukum dan Pembangunan, 50(2).

Marzuki, P. M. (2021). Legal research (Revised ed.). Kencana.

Miru, A., & Yodo, S. (2018). Consumer protection law. RajaGrafindo Persada.

Mongabay Indonesia. (2025, November 27). How is the legal process in the Cikande radioactive contamination case? Mongabay Indonesia.

Pratama, N. L., & Sulaiman, R. A. (2026). Reconstructing criminal liability models for the dissemination of false information in the Indonesian criminal justice system. Golden Ratio of Law and Social Policy Review, 5(2). https://doi.org/10.52970/grlspr.v5i2.2135

Prasetyo, E. (2020). The role of the state in food consumer protection. Jurnal RechtsVinding, 9(2).

Putra, D. R. (2020). The competitiveness of Indonesian shrimp exports in the international market. Jurnal Sosial Ekonomi Kelautan dan Perikanan.

Putra, M. R. (2021). Cross-sectoral coordination in environmental supervision. Jurnal Ilmu Hukum, 8(2).

Rahardjo, S. (2020). The rule of law state and the protection of public interests. Jurnal Konstitusi, 17(4).

Rahmadi, T. (2022). Environmental law in Indonesia. RajaGrafindo Persada.

Ramadhan, F. Y. (2023). Radioactive waste management as hazardous and toxic waste (B3) from the perspective of environmental law. Jurnal Ilmu Lingkungan.

Reuters. (2025). Indonesia says 22 plants in industrial zone near Jakarta contaminated by caesium-137. Reuters.

Soekanto, S., & Mamudji, S. (2019). Normative legal research: A brief overview. Rajawali Pers.

Sugiarto, A. (2025). The principle of legality in corporate criminal liability for environmental crimes in Indonesia. Golden Ratio of Law and Social Policy Review, 5(1). https://doi.org/10.52970/grlspr.v5i1.1724

Steinhauser, G., Brandl, A., & Johnson, T. E. (2014). Comparison of the Chernobyl and Fukushima nuclear accidents: A review of the environmental impacts. Science of the Total Environment, 470–471, 800–817. https://doi.org/10.1016/j.scitotenv.2013.10.029

Suseno, H. (2017). Distribution of Cesium-137 radionuclides in Indonesian marine waters and its implications for the marine environment. Jurnal Ilmu dan Teknologi Kelautan Tropis.

Triana, N., & Izza, F. N. (2020). The perspective of Islamic law on the application of the polluter pays principle in Indonesian environmental law. Al-'Adalah, 17(2), 359–382. https://doi.org/10.24042/adalah.v17i2.8223

U.S. Food and Drug Administration. (2025). FDA advises public not to eat, sell, or serve certain imported frozen shrimp from an Indonesian firm. U.S. Food and Drug Administration.

Venturi, S. (2021). Cesium in biology, pancreatic cancer, and controversy in high and low radiation exposure damage—Scientific, environmental, geopolitical, and economic aspects. International Journal of Environmental Research and Public Health, 18(17), Article 8934. https://doi.org/10.3390/ijerph18178934

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ISSN [Online]: 2808-2923

Wahyuni, A. S. (2020). The precautionary principle in hazardous and toxic waste management. Jurnal Legislasi Indonesia.

World Health Organization. (2020). Health effects of ionizing radiation. World Health Organization.

Yuliana, S. P. (2024). Supervision of fishery food products in international trade. Jurnal Hukum dan Pembangunan.

2026. The Author(s). This open-access article is distributed under a Creative Commons Attribution (CC-BY-SA) 4.0 license.