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Application of the Precautionary Principle in Hazardous Waste Transportation: Environmental Law Study on Licensing and Supervision Systems

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Abstract

This study aims to analyze the application of the principle of prudence in the legal system for the transportation of hazardous and toxic materials (B3) in Indonesia through a case study of the sodium hydroxide (NaOH-48) leak by CV. Yasindo Multi Pratama in West Bandung Regency.

The method used in this study is the doctrinal legal method with a normative juridical approach, accompanied by an empirical case study of violations of technical permits, vehicle feasibility, and driver certification in the B3 transportation process.

The novelty of this research lies in the integration of analysis between the principle of prudence as an environmental law principle and the technical transportation licensing system, which has not been studied in depth in the context of cross-sectoral supervision.

The results of the study show that the application of the precautionary principle is still not effective because of its formalistic nature, which has prevented its systemic implementation. Furthermore, weak coordination between agencies, low compliance with regulations by business actors, and the absence of adequate preemptive mechanisms in the form of education and socialization are also factors that hinder the effectiveness of this principle.

This study concludes that the effective application of the principle of prudence in the transportation of hazardous materials requires a reformulation of policies that emphasizes the integration of preemptive, preventive, and repressive measures, while affirming the multiple responsibilities of the government as the holder of the public protection mandate and business actors as the main subjects of the principle of strict liability.

Keywords: NaOH-48; B3 Transportation; Prudence; Regulation

Abstrak

Penelitian ini bertujuan *untuk menganalisis penerapan prinsip kehati-hatian dalam sistem hukum pengangkutan bahan berbahaya dan beracun (B3) di Indonesia melalui studi kasus kebocoran natrium hidroksida (NaOH-48) oleh CV. Yasindo Multi Pratama di Kabupaten Bandung Barat.*

Metode penelitian *ini menggunakan metode hukum doktrinal dengan pendekatan yuridis normatif, disertai studi kasus empiris terhadap pelanggaran izin teknis, kelayakan kendaraan, serta sertifikasi pengemudi dalam proses pengangkutan B3.*

Kebaruan penelitian *ini terletak pada integrasi analisis antara asas kehati-hatian sebagai prinsip hukum lingkungan dan sistem perizinan teknis transportasi, yang selama ini belum*

dikaji secara mendalam dalam konteks pengawasan lintas sektor.
Hasil penelitian *menunjukkan bahwa penerapan prinsip kehati-hatian masih belum berjalan secara efektif karena sifatnya yang formalistik sehingga belum terimplementasi secara sistemik. Lebih lanjut, lemahnya koordinasi antarinstansi, rendahnya kepatuhan pelaku usaha terhadap regulasi, serta absennya mekanisme preemtif berupa edukasi dan sosialisasi yang memadai juga ikut menjadi faktor yang mengahambat efektivitas prinsip ini.*
Kesimpulan *Penelitian ini bahwa efektivitas penerapan prinsip kehati-hatian dalam pengangkutan B3 menuntut reformulasi kebijakan yang menekankan keterpaduan antara langkah preemtif, preventif, dan represif, dengan menegaskan tanggung jawab berlapis antara pemerintah sebagai pemegang mandat perlindungan publik dan pelaku usaha sebagai subjek utama prinsip tanggung jawab mutlak (strict liability).*
Kata Kunci: *NaOH-48; Pengangkutan B3; Kehati-Hatian; Regulasi*

1. INTRODUCTION

In the era of modern industrialization, the mobility of hazardous and toxic chemicals (B3) through the national transportation system is inevitable. The transportation of B3 not only supports the continuity of production processes in the manufacturing, mining, and energy sectors, but also poses a great risk to human safety and environmental sustainability.[1] Data from the Ministry of Environment and Forestry (KLHK) shows that in 2023 Indonesia produced around 39.3 million tons of hazardous waste, of which around 84% was managed in accordance with regulations.[2] Although the proportion of management shows an increase, the aspect of transportation as one of the vulnerable points in the B3 logistics chain is often overlooked and does not yet have an adequate monitoring system. The legal issue that arises is the weak implementation of the principle of prudence as a legal obligation in the licensing, supervision, and accountability systems for B3 transportation.

In the implementation of hazardous waste management in Indonesia today, there are still discrepancies between legislation and technical practices in the field, weak synergy between authorities in supervising hazardous waste transportation, and low compliance by business actors with technical safety aspects, such as vehicle types, technical permits, and driver certification. Many hazardous material transporters in Indonesia do not understand the classification of hazardous materials, have not received special training, and do not use vehicles that comply with international safety standards.[3] This situation is exacerbated by weak oversight, which opens the door to negligence and evasion of legal responsibility.

Sodium hydroxide (NaOH-48) is a chemical that poses a high risk, especially in

[1] S. Rizvanli and B. Shahpalangova, "Assessment of the Hazard Risk That May Arise During the Transportation of Hazardous Chemicals by Vehicle Transport," *Təbiət və Elm* 6, no. 8 (2024): 23–37, https://doi.org/10.36719/2707-1146/47/23-37.

[2] Hilda B Alexander, "SBI Ikut Pulihkan Lahan Tercemar Limbah B3 Di Indonesia," Kompas (Lestari), 2023, https://lestari.kompas.com/read/2023/09/19/060000886/sbi-ikut-pulihkan-lahan-tercemar-limbah-b3-di-indonesia.

[3] Emi Septiana Hutabarat, "Analisa Potensi Risiko Keselamatan Pengemudi Barang Bahan Berbahaya Dan Beracun Berdasarkan Agreement for Transport of Dangerous Goods by Road (ADR)," *Jurnal Penelitian Transportasi Darat* 21, no. 2 (2019): 125–30, https://doi.org/10.25104/jptd.v21i2.1564.

concentrated solutions. This material is widely used in various industries, from textiles, metal processing, industrial cleaning, to wastewater treatment.[4] Its highly caustic nature[5] making it dangerous for both humans and the environment if not handled properly. Errors in handling sodium hydroxide in industrial processes can trigger exothermic reactions[6] dangerous and systematically damaging to equipment infrastructure.[7] In transportation, the risk of leakage, spillage, or explosion due to failure to implement procedures and principles of caution is one of the factors that must be considered.

This is not merely a hypothesis. An incident involving the transport of hazardous materials occurred in late 2024 in Karawang, where sodium hydroxide leaked. Two workers were named as criminal suspects for failing to follow chemical transport safety procedures.[8] A similar case also occurred in West Bandung, where chemical liquids flowed onto public roads and polluted the surrounding environment.[9] These incidents not only impact the environment, but also raise questions about how seriously businesses are implementing the principle of caution in every stage of hazardous waste transportation.

The precautionary principle is one of the fundamental principles that requires every business activity that poses a risk of environmental damage to take anticipatory measures even if there is no definitive scientific evidence regarding the level of danger. This principle applies not only to the waste disposal stage, but also covers the entire life cycle of hazardous materials, including the transportation phase, which poses the greatest potential risk of unexpected accidents.[10] In Indonesia, the principle of precaution has been adopted normatively in various legal instruments such as Law No. 32 of 2009 concerning Environmental Protection and Management, but its implementation still needs to be strengthened through enforcement mechanisms, supervision, and strict sanctions, especially for the transportation of hazardous materials.

The sodium hydroxide leak incident involving a transport company, CV. Yasindo Multi Pratama, highlights the weak implementation of the precautionary principle, which has the potential to cause environmental accidents. During an inspection conducted by the West

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[4] Babar Imran et al., "Removal and Recovery of Sodium Hydroxide (NaOH) from Industrial Wastewater by Two-Stage Diffusion Dialysis (DD) and Electrodialysis (ED) Processes," *Desalination and Water Treatment* 57, no. 17 (2016): 7926–32, https://doi.org/10.1080/19443994.2015.1048742.

[5] Kaustik berarti dapat terbakar, berkarat, hancur, atau rusak akibat peristiwa kimia (kbbi.web.id).

[6] Eksotermik adalah reaksi yang melepaskan energi atau panas (kbbi.web.id).

[7] B. Tropenauer, D. Klinar, and J Golob, "Improved Understanding of Sodium Hydroxide Concentration Role and Kinetic Model of Cryolite Reactive Extraction in Cathode Spent Pot Linings," *Polish Journal of Chemical Technology* 23, no. 1 (2021): 37–44, https://doi.org/10.2478/pjct-2021-0006.

[8] Irvan Maulana, "2 Pegawai Pabrik Jadi Tersangka Kebocoran Gas Caustic Soda Karawang," detikJabar, 2024, https://www.detik.com/jabar/berita/d-7178673/2-pegawai-pabrik-jadi-tersangka-kebocoran-gas-caustic-soda-karawang.

[9] Bagus Puji Panuntun and Reni Susanti, "DLH Ungkap Cairan Kimia Yang Banjiri Jalan Di Bandung Barat: Soda Api," Kompas (Bandung), 2024, https://bandung.kompas.com/read/2024/12/24/122527778/dlh-ungkap-cairan-kimia-yang-banjiri-jalan-di-bandung-barat-soda-api.

[10] Joshua Wijaya Proyogo, "Balancing Risk and Caution: The Precautionary Principle in Indonesian Environmental Law Context," *Universitas Negeri Semarang in Indonesian Journal of Environmental Law and Sustainable Development* 3, no. 1 (2024), https://doi.org/10.15294/ijel.v3i1.7889.

Bandung Regency Environment Agency (DLH KBB), CV. Yasindo was found to be transporting hazardous materials without a specific technical permit and did not meet the B3 transport vehicle standards set by the Ministry of Transportation.[11] This indicates that there are regulatory loopholes that are being exploited by businesses due to weak oversight systems or unclear jurisdictional boundaries between relevant agencies.

Daniel Crowl and Joseph Louvar, in their book *Chemical Process Safety: Fundamentals with Applications*, state that in neutral weather conditions, such as when the sky is clear with no rain and low wind speeds, spilled chemicals tend to accumulate on the ground surface due to low vertical and horizontal dispersion.[12] In the context of transporting hazardous materials such as sodium hydroxide, these conditions have the potential to cause maximum exposure in the area surrounding the spill, thereby increasing the potential for acute risks to humans and the ecosystem.

Soil contaminated with sodium hydroxide can undergo extreme pH changes that destroy microbial communities and permanently degrade soil quality.[13] Sodium hydroxide also has high mobility properties that can seep into the subsoil and contaminate groundwater, even damaging aquatic ecosystems through bioaccumulation. The long-term and systemic impact of sodium hydroxide contamination reinforces the urgency of applying the precautionary principle comprehensively in the B3 transportation system.

According to Zhang, Cheng, and Gai, the transportation of B3 from the perspective of integration between risk management and technical licensing systems is still very limited because accidents involving the transportation of hazardous chemicals still focus on mapping incidents and post-incident handling, while attention to aspects of ex-ante control[14] such as licensing procedures, vehicle specifications, and the competence of transport operators are still relatively lacking.[15] In fact, from a legal and technical perspective, this aspect is a crucial point that determines the safety of hazardous material transportation.

In line with these findings, research by Gholamizadeh et al. on hazmat transportation safety also revealed that the effectiveness of hazardous chemical transportation regulations is greatly influenced by the level of coordination between government agencies and the implementation of a transparent digital-based permit system. Their research emphasizes the importance of cross-agency governance in preventing hazardous chemical incidents.[16] Both

[11] Wawancara dengan Adhi Setyowibowo, Pejabat Pengawas Lingkungan Hidup Ahli Muda, [22 Mei 2025].
[12] Daniel A. Crowl and Joseph F. Louvar, *Chemical Process Safety: Fundamentals with Applications*, Edition 4 (Boston: Pearson Education, 2019).
[13] J. Shi et al., "Neutralization of Industrial Alkali-Contaminated Soil by Different Agents: Effects and Environmental Impact," *Sustainability* 14, no. 10 (2022): 5850, https://doi.org/10.3390/su14105850.
[14] *Ex-ante control* merujuk pada mekanisme pengendalian yang dilakukan sebelum kegiatan berlangsung, sehingga bersifat preventif.
[15] W. Zhang, W. Cheng, and W. Gai, "Hazardous Chemicals Road Transportation Accidents and The Corresponding Evacuation Events from 2012 to 2020 in China: A Review," *International Journal of Environmental Research and Public Health* 19, no. 22 (2022): 15182, https://doi.org/10.3390/ijerph192215182.
[16] Kamran Gholamizadeh et al., "Advancing Hazardous Materials Transport Safety: Systematic Insights on Risks, Challenges, and Research Gaps," *Journal of Safety Science and Resilience* 7, no. 1 (2024): 100226, https://doi.org/10.1016/j.jnlssr.2025.100226.

studies consistently show that the lack of integration between legal, technical, and institutional approaches is a major weakness.

Based on the above explanation, it can be seen that previous studies have focused on the technical and managerial aspects of hazardous material transportation safety, while studies linking the principle of prudence with legal mechanisms and technical licensing within the national scope are still limited. Therefore, the gap in this research lies in the lack of integration between the principle of precaution as an ethical and legal basis and the technical aspects of licensing and supervision of B3 transportation. This study attempts to fill this gap by combining a normative legal approach and empirical analysis based on the actual case of NaOH-48 leakage in West Bandung Regency.

The novelty of this research lies in the integration of the principle of prudence as an ethical and legal basis with the technical aspects of licensing in analyzing the entire hazardous chemical transportation system. This discussion is reinforced by an actual case study of a sodium hydroxide leak by CV. Yasindo Multi Pratama on December 24, 2024, as the basis for empirical analysis. This case shows serious violations in the form of transportation without technical permits and the use of vehicles that do not meet B3 standards, as well as weak integration of supervision between relevant authorities.

In addition, this study will present a technical and legal analysis of the main components of the B3 transportation system, including vehicle types, licensing systems, and driver certification, within the framework of risk governance. The aim is to answer fundamental questions about how the principle of precaution can be translated concretely into policy design, verification systems, and cross-sectoral oversight procedures, and whether existing regulations are capable of directing the transportation process in accordance with procedures. Thus, the discussion in this article is academically relevant and provides practical contributions to policymakers, industry players, and the wider community. The expected outcome is to strengthen the B3 transportation governance system not only administratively, but also based on the principles of sustainability, safety, and ecological justice.

2. METHOD

This study uses a doctrinal legal method with a normative juridical approach to analyze the regulation and governance of hazardous and toxic material (B3) transportation in Indonesia. The analysis focuses on the effectiveness of legal instruments in the form of technical licensing, vehicle requirements, and operator competence in implementing the principle of prudence. The case study of sodium hydroxide leakage by CV. Yasindo Multi Pratama in December 2024 is used as secondary legal material to illustrate the gap between legal norms and B3 transportation practices in the field.

3. DISCUSSION

The gap between regulations governing the transportation of hazardous materials and their implementation in the field has raised serious concerns regarding human safety and environmental preservation. Therefore, the analysis in this discussion will focus on how the precautionary principle as a fundamental principle of environmental law in the B3

transportation legal system in Indonesia is applied by examining licensing obligations, transportation facility standards, driver competency certification, and the effectiveness of cross-sectoral supervision. This discussion presents an analytical mapping of the B3 transportation legal system in Indonesia to identify weaknesses in the governance system, from the licensing stage, technical suitability of transport facilities, operator competence, to the effectiveness of cross-sectoral supervision, thereby providing a clear picture of the root causes of the problems and the direction for future improvements.

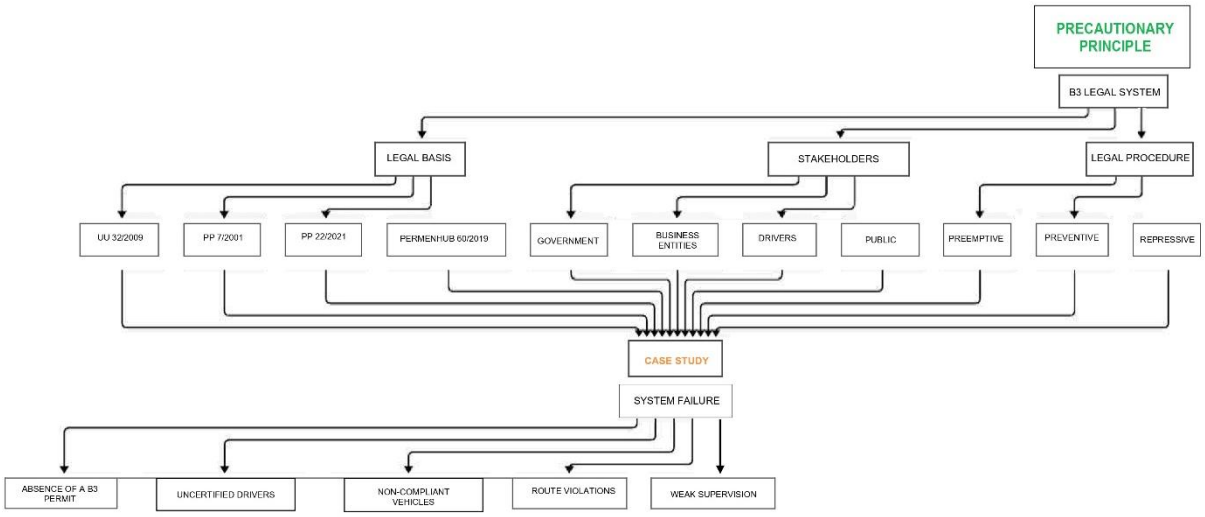

Figure 1. Schematic of the Hazardous Waste Transportation Legal System in Indonesia

The above diagram illustrates the complexity and integration of an ideal hazardous waste transportation legal system, comprising three tiered pillars (preemptive, preventive, repressive) and multi-stakeholders with their respective responsibilities. In reality, this seemingly comprehensive system has experienced disintegration and systemic failure, as reflected in the case of sodium hydroxide leakage by CV. Yasindo Multi Pratama. The following discussion will analyze each component in this scheme and identify where the critical points of failure occurred.

3.1. The Principle of Prudence in B3 Management

The precautionary principle is a key foundation of modern environmental law, emphasizing the need for preventive action against potential environmental hazards, even when the available scientific evidence is not yet conclusive.[17] This principle contains the moral and legal mandate that uncertainty is not a reason to delay protective measures. This concept was first explicitly formulated in Principle 15 of the 1992 Rio Declaration, which states that where there are threats of serious or irreversible damage to the environment, lack of full scientific certainty shall not be used as a reason for postponing cost-effective preventive measures.[18] This formulation emphasizes that scientific uncertainty should not be used as an

[17] Karan Raj Sachdeva, "Balancing Progress and Protection: The Precautionary Principle in Global Environmental Governance," *International Journal For Multidisciplinary Research* 6, no. 5 (2024), https://doi.org/10.36948/ijfmr.2024.v06i05.28227.

[18] L. Drivdal and J. P. van der Sluijs, "Pollinator Conservation Requires a Stronger and Broader Application of the

excuse to delay environmental protection policies. This principle has become a global legal reference in the drafting of various international environmental agreements and national laws in various countries.

In the context of environmental law, this principle serves as a normative standard that binds every activity that has the potential for ecological impact, including the transportation of hazardous materials, which inherently carries direct risks to soil, water, and air quality, as well as public health. Thus, the precautionary principle not only regulates technical aspects of prevention, but also directs how the state and business actors must act to proactively protect the environment.

The precautionary principle in the Rio Declaration is outlined not only as a technical norm, but also as a symbol of an ethical approach to sustainability. This principle has undergone shifts in meaning and interpretation in various jurisdictions. On the one hand, this principle is considered a form of vigilance against environmental hazards, but on the other hand, it is often misinterpreted as an obstacle to technological and economic progress. The terms in the Rio principle are often interpreted inconsistently, creating new room for discussion regarding normative clarity and the effectiveness of its application in national legal systems, especially in developing countries.[19]

This debate becomes important when linked to the transportation of hazardous materials, because ambiguity in the interpretation of the precautionary principle can have direct implications for the quality of regulations, the effectiveness of oversight, and the degree of environmental protection. The environmental law perspective emphasizes that the interpretation of this principle must always favor the prevention of ecological damage, rather than short-term economic interests.

To reinforce the application of the precautionary principle, the concept of from cradle to grave emphasizes the importance of full accountability for the environmental impact caused throughout the chain of activities, including the crucial stage of transportation.[20] This concept was born in the 1970s to introduce the idea of waste management that covers the entire cycle of a product, from production to final disposal. This concept gave rise to the practices of recycling, downcycling, and upcycling.[21]

Furthermore, the concept of from cradle to grave has evolved into from cradle to cradle, which is sustainability without waste through the reuse of materials, renewable energy, and product design based on ecosystems.[22] This development demonstrates efforts to expand the

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Precautionary Principle," *Current Opinion in Insect Science* 46 (2021): 95–105, https://doi.org/10.1016/J.COIS.2021.04.005.

[19] S Axon, "Unveiling Understandings of the Rio Declaration's Sustainability Principles: A Case of Alternative Concepts, Misaligned (Dis)Connections, and Terminological Evolution," *Sustainability* 16, no. 6 (2024): 2600, https://doi.org/10.3390/su16062600.

[20] Faisal Khan, *Methods in Chemical Process Safety*, Edition 20 (Amsterdam: Academic Press (Elsevier)., 2017).

[21] Muhammad Kresna Adi Putra and Yun Yun, "Analisis Pengelolaan Limbah B3 Pada Proses Pengangkutan Dalam Rangka Efesiensi Pada PT Pratama Karya Nugraha," *Jurnal Lentera Bisnis* 14, no. 3 (2025): 3398–99, https://doi.org/10.34127/jrlab.v14i3.1741.

[22] Y. Yang, "The Application and Reflection of Cradle to Cradle in Industrial Design," *Academic Journal of Science and Technology* 9, no. 2 (2024): 221–23, https://doi.org/10.54097/39gtam48.

application of the precautionary principle, which is not limited to preventing environmental risks, but also encourages the establishment of production and distribution systems that are in harmony with the environment. This concept emphasizes that the transportation of hazardous materials must be placed within the framework of sustainable responsibility. Thus, regulations on the transportation of hazardous materials need to be designed not only to prevent incidents, but also to ensure long-term environmental sustainability.[23]

The environmental law perspective views this concept as the basis for sustainable ecological responsibility. In the context of hazardous material transportation, this means that every movement of hazardous materials through public spaces must be treated as a potentially polluting activity, so that the state is obliged to establish strict legal standards to prevent damage throughout the entire cycle of these materials.

Meanwhile, in the context of Indonesian environmental law, the precautionary principle has gained formal legitimacy through Article 2 of Law No. 32 of 2009, which lists this principle as one of the main principles of environmental protection. This principle serves not only as an ethical guideline, but also as a normative legal basis for administrative decision-making, such as the granting of environmental permits, the preparation of environmental impact assessment (EIA) documents, and risk management training.[24]

From the planning stage, the precautionary principle is used to anticipate risks, rather than simply responding after impacts occur. The application of this principle is vital given the high potential for harm to human health and environmental integrity.[25] The success of accident prevention in the chemical industry is not only determined by the technical reliability of equipment or operational vehicles, but also depends on the integration of a multi-layered protection system that is capable of functioning independently and complementing each other.

The layers of protection approach explains that each layer of control, from inherently safe process design and safety instrumentation systems to emergency response procedures, must be designed to remain functional even if other layers fail.[26] In other words, an effective prevention strategy requires technical readiness, precise planning, personnel training, and a structured incident communication system to ensure a quick and accurate response when an emergency occurs.

In Indonesia, the precautionary principle has been formally legitimized through Article 2 of Law No. 32 of 2009, which affirms it as the main principle in the implementation of

[23] I Nyoman Budiartha and Mohammad Ervin Ardani, "Konsep Hukum Pengelolaan Limbah Berbahaya Dan Beracun (B3) Dalam Perspektif Hukum Lingkungan," *Kertha Wicara: Journal Ilmu Hukum* 12, no. 4 (2025): 432–443, https://ojs.unud.ac.id/index.php/kerthawicara/article/view/104136.

[24] I. G. A. K. R. Handayani, C. Yosiana, and S Kongrawd, "Reform of Environmental Approval Policy for Renewable Energy in Indonesia," *Journal of Sustainable Development and Regulatory Issues* 3, no. 2 (2025): 286–323, https://doi.org/10.53955/jsderi.v3i2.101.

[25] F. A. Cahyani and A. W. Anditya, "Implementation of Precautionary Principles in Environmental Impact Assessment (EIA) in Indonesia," *Unifikasi: Jurnal Ilmu Hukum* 11, no. 1 (2024): 40–45, https://doi.org/10.25134/unifikasi.v11i01.765.

[26] Khan, *Methods in Chemical Process Safety*.

environmental protection. This principle is not merely declarative, but serves as a normative basis for policy, licensing, and administrative decision-making. Its implementation is evident in the obligation to prepare an Environmental Impact Assessment (EIA), environmental licensing mechanisms, and risk management instruments that must be fulfilled before an activity can be carried out. This principle is reinforced through sectoral regulations, such as the transportation of hazardous and toxic materials (B3), which requires compliance with vehicle technical standards, operational feasibility, and operator competence. Thus, the precautionary principle serves a dual function: as a normative guideline that directs environmental policy and as an operational framework that ensures high-risk activities are carried out carefully, measurably, and accountably.

In its implementation, the precautionary principle plays a central role as the foundation for decision-making and planning activities that have the potential to cause negative impacts on ecological risks. This principle is not only interpreted as a moral or ethical guideline in preserving the environment, but has also been fully integrated as an integral part of the administrative legal system that regulates the licensing process, the preparation of environmental documents, and the provision of training for human resources involved in high-risk activities. Ideally, this principle should be applied proactively from the outset, at the planning stage (ex-ante), to ensure that potential hazards are identified and managed before an activity begins.[27] This preventive approach is crucial in the transportation of hazardous and toxic materials (B3), which inherently pose risks to human health and the environment.

This is where the direct relevance between the precautionary principle and environmental law is clearly evident: the higher the risk intensity of an activity, the greater the obligation of the state and business actors to implement stricter protection standards. The transportation of hazardous materials, with the risk of pollution that can occur at any time along the route, is one of the areas most in need of the implementation of this principle.

The principle of precaution in environmental law serves to encourage all parties to take preventive measures before environmental damage occurs. In this context, protection efforts are not only preventive but also preemptive. Preemptive measures are the earliest line of defense, which are non-punitive and aim to prevent the emergence of intent or ignorance that could lead to violations. These measures include legal counseling, public and business education on B3 risks, dissemination of clear and accessible licensing procedures, and transportation safety campaigns. The effectiveness of preemptive measures creates voluntary compliance based on awareness. Thus, the precautionary principle not only regulates how to prevent incidents, but also how to shape risk-aware behavior before activities take place.

The sodium hydroxide leak incident involving CV. Yasindo Multi Pratama on December 24, 2024, is a clear illustration of negligence in applying these principles. Based on interviews with officials from the West Bandung Regency Environment Agency, it was revealed that the company did not have an official permit to transport hazardous materials, and the driver of the transport vehicle did not have a competency certificate. This shows a failure to meet the

[27] Proyogo, "Balancing Risk and Caution: The Precautionary Principle in Indonesian Environmental Law Context."

administrative and technical requirements that should be part of a precautionary scheme.[28]

Furthermore, this negligence was exacerbated by the driver's decision to use public roads as a distribution route, rather than toll roads as recommended for the transport of high-risk chemicals. Liu et al. explain that the use of restricted access routes such as toll roads tends to be safer because it reduces the level of risk exposure to the general public, so this disregard further demonstrates the weak application of the principle of caution.[29] The driver claimed that fuel was limited, but this decision significantly increased the risk exposure to the general public. The choice of route demonstrated negligence in logistics and risk management, which ultimately contributed to the incident.

Another essential technical aspect in the implementation of the principle of prudence lies in the principle of designing safer vehicles for transporting hazardous and toxic materials (B3). Risk reduction cannot be achieved simply by adding protective equipment, but must begin with the technical characteristics of the system itself. Ideally, B3 transport vehicles should be equipped with anti-corrosive materials to withstand hazardous chemical reactions, high-pressure joints and seals to prevent leaks, and a release valve system designed to prevent spillage during filling and emptying. In addition, the segregation principle in the guidelines recommends that risky elements be physically separated, for example by rearranging the position of tanks, adding protective walls, or implementing an overhead loading system instead of an underfloor system.[30] The absence of these features indicates a weak integration of the precautionary principle in the design of hazardous material transportation and has the potential to increase technical risks in the field, as reflected in the case of sodium hydroxide leakage by CV. Yasindo.

Violations of the principle of prudence do not only have administrative consequences. Article 508 of Government Regulation No. 22 of 2021 states that activities that cause pollution without an environmental permit are subject to sanctions in the form of government coercion, written warnings, administrative fines, suspension of business permits, and/or revocation of business permits.[31] Although the company was cooperative and willing to cover residents' losses, its disregard for the principle of due care still placed it in a position of violating the law, both formally and substantively.

From a broader perspective, this case shows that the principle of precaution is not merely legal rhetoric, but rather a normative and operational framework that has a real impact on environmental governance, public safety, and corporate social responsibility. The precautionary principle serves as the main compass to ensure that every stage of operations, from licensing, planning, training, to technical design, can be carried out in accordance with

[28] Wawancara dengan Adhi Setyowibowo, Pejabat Pengawas Lingkungan Hidup Ahli Muda, [22 Mei 2025].

[29] L. Liu et al., "Research on Route Optimization of Hazardous Materials Transportation Considering Risk Equity," *Sustainability* 13, no. 16 (2021): 9427, https://doi.org/10.3390/su13169427.

[30] "Egyptian Process Safety Management Steering Committee (PSMSC Egypt) Dan PSM Technical Subcommittee (PSMTC)," *Inherently Safer Design (ISD) Guideline: EGPC-PSM-GL-003* (Cairo, 2022).

[31] Pasal 508 Peraturan Pemerintah Nomor 22 Tahun 2021 tentang Penyelenggaraan Perlindungan dan Pengelolaan Lingkungan Hidup.

high standards of safety and environmental protection. Failure to implement it, as in the case of CV. Yasindo, should be seen as an alarm for strengthening regulations and supervision, not merely as an administrative incident.

3.2. Legal Procedures for Transporting Hazardous Materials in Indonesia

The transportation of hazardous and toxic materials (B3) is an activity that poses a high risk to human safety and the environment, and is therefore legally categorized as an activity that must meet certain licensing and technical standards.[32] The regulation of B3 transportation in Indonesia is based on a comprehensive and integral approach to environmental law. The comprehensive nature is reflected in the regulation of technical aspects that require the convergence of various disciplines, ranging from chemistry (hazard classification), engineering (vehicle design), transportation safety, to public health. Meanwhile, the integral nature requires comprehensive management of hazardous waste from cradle to grave, where the transportation stage is a critical link connecting waste producers with processing or disposal sites. Integration between sectors is a necessity in realizing this approach, which involves the Ministry of Environment and Forestry, the Ministry of Transportation, local governments, and law enforcement agencies.

In Indonesia, the basic provisions regarding the procedures for transporting hazardous materials are regulated in a number of hierarchical regulations, ranging from government regulations to sectoral technical regulations. Article 13 paragraph (1) of Government Regulation No. 74 of 2001 concerning the Management of Hazardous and Toxic Materials (B3) stipulates that the transportation of B3 must use means that are fit for operation and follow transportation procedures in accordance with applicable laws and regulations.[33] This provision reflects that the transportation of hazardous materials cannot be viewed as a normal logistics activity, but rather as an activity that poses a high level of risk to human safety and environmental sustainability. Therefore, compliance with technical aspects such as the suitability of transportation facilities, the implementation of safety protocols, and adherence to operational standards are absolute obligations that must be strictly monitored by the competent authorities. These provisions emphasize that the state has a strategic role in ensuring that all B3 transportation activities are carried out safely, responsibly, and in accordance with applicable laws.

Article 12 of Minister of Transportation Regulation No. PM 60 of 2019 stipulates that the transportation of hazardous materials must meet a number of technical and operational criteria. These provisions include strengthening the obligation to use vehicles for their intended purpose, traveling on roads that meet the required road class, and the availability of adequate loading and unloading facilities. In addition, vehicles must comply with maximum speed limits, may only be parked in designated locations, and must operate in accordance with

[32] F. N. Huzaini et al., "Enterprise Risk Management in Hazardous Waste Processing for Industrial Environmental Safety," *2025 4th International Conference on Creative Communication and Innovative Technology (ICCIT)*, 2025, 1–7, https//doi.org/10.1109/ICCIT65724.2025.11167745.

[33] Pasal 13 ayat (1) Peraturan Pemerintah Nomor 74 Tahun 2001 tentang Pengelolaan Bahan Berbahaya dan Beracun (B3).

routes established by the authorities.[34] This set of requirements emphasizes that the transportation of hazardous materials cannot be equated with the distribution of ordinary goods, as it carries a high potential risk to public safety and the environment. Thus, these regulations play an important role in ensuring that safety, traffic management, and risk control aspects are integrated into B3 logistics transportation practices in Indonesia.

Although the regulatory framework for the transportation of hazardous and toxic materials (B3) in Indonesia has been formulated in detail, its implementation shows that it is still far from ideal. A number of issues such as vehicles without hazard labels, incomplete cargo documents, and drivers without competency certification are still commonly found in daily operational practices. Based on the 2024–2029 National Occupational Safety and Health (OSH) Program, it is also mentioned that the challenges of OSH implementation in Indonesia are still marked by an outdated legal framework, limited application and enforcement of OSH norms, minimal human resource capacity and supporting institutions, a lack of integration of reporting systems, and weak inter-agency coordination.[35] These factors indicate a gap between regulations and practices, which implies that the risk of workplace accidents and safety violations in operational activities, including the transportation of hazardous materials, remains high.

The case of sodium hydroxide spillage by CV. Yasindo Multi Pratama along the Purwakarta–Padalarang highway on December 24, 2024 shows that the implementation of hazardous material transportation regulations is still far from ideal. Based on interviews with officials from the West Bandung Regency Environment Agency (DLH KBB), a number of crucial violations of the legal procedures for transporting hazardous materials were found.[36] First, CV. Yasindo does not have an official B3 transportation permit from the Ministry of Environment or the Directorate General of Land Transportation, but only holds a public transportation permit. In fact, a specific permit for B3 transportation must cover transportation, temporary storage, and reporting of hazardous cargo. The provisions of Article 36 paragraph (1) of Law No. 32 of 2009 require every business that is required to have an AMDAL or UKL-UPL to obtain an environmental permit, while Article 40 paragraph (1) of the same law stipulates that an environmental permit is a prerequisite for obtaining a business permit.[37] In line with this, Article 12 of Government Regulation No. 74 of 2001 requires the inclusion of a Material Safety Data Sheet in every hazardous material transportation activity, while Article 13 requires the use of transportation facilities that are fit for operation in accordance with the transportation procedures established by the competent authority.[38] Thus, CV. Yasindo's actions not only violated B3 licensing obligations, but also technical transportation procedures focused on

[34] Pasal 12 Peraturan Menteri Perhubungan Nomor PM 60 Tahun 2019 tentang Penyelenggaraan Angkutan Barang dengan Kendaraan Bermotor di Jalan.
[35] "Program Keselamatan Dan Kesehatan Kerja Nasional Indonesia 2024–2029" (Jakarta, 2024).
[36] Wawancara dengan Adhi Setyowibowo, Pejabat Pengawas Lingkungan Hidup Ahli Muda, [22 Mei 2025].
[37] Undang-Undang Republik Indonesia Nomor 32 Tahun 2009 tentang Perlindungan dan Pengelolaan Lingkungan Hidup, Pasal 36 ayat (1) dan Pasal 40 ayat (1).
[38] Peraturan Pemerintah Republik Indonesia Nomor 74 Tahun 2001 tentang Pengelolaan Bahan Berbahaya dan Beracun, Pasal 12 dan Pasal 13.

safety and risk mitigation.

Second, the vehicle driver did not have a special B3 transport certification, as required by technical regulations. In fact, the driver is the first person involved in an incident, and the lack of special training indicates the weakness of the company's internal system preparedness. DLH KBB confirmed that the truck driver did not even know that B3 transporters must be certified. This action clearly violates Article 45 letter f of the Regulation of the Minister of Transportation of the Republic of Indonesia Number 60 of 2019, which stipulates that special transportation companies must not only have a license to operate special goods transportation, but also ensure that all B3 handling personnel are officially certified.[39] Non-compliance with these provisions not only violates the law, but also increases the risk of accidents, exposure to hazardous substances, and potential environmental damage along the transport route.

Violations of certification requirements not only reflect corporate negligence, but also reveal a more fundamental failure at the policy level, namely the weakness of the preemptive subsystem. In the context of B3 transportation, ideal preemptive measures should include a proactive national education program for prospective drivers, easy access to regulatory information and technical guidelines, and the dissemination of Safety Data Sheets (SDS) as a key educational tool. The ineffectiveness of this preemptive subsystem in the case of sodium hydroxide leakage is clearly reflected in the admission of the CV Yasindo driver that he was unaware of the certification and special permit requirements. This shows that systemic failure does not only occur at the preventive (supervision) stage, but has already begun at the most basic stage, namely the lack of socialization, education, and guidance that reaches all business actors, especially small and medium-sized enterprises.

Third, from a technical perspective, transportation was not carried out via toll roads as it should have been. Although there are no rules that explicitly require the use of toll roads, Article 12 letters b and f of Regulation of the Minister of Transportation of the Republic of Indonesia Number 60 of 2019 stipulate that B3 transportation must use road infrastructure in accordance with the specified road class and route.[40] This provision indicates that routes such as toll roads are safer because they have adequate infrastructure and minimal interaction with the general public. In reality, drivers choose regular routes due to fuel shortages. This action violates the designated route and increases the risk of exposure to hazardous substances to the public. As a result, sodium hydroxide leaked and dripped from Kampung Cigentur to Cikamuning, covering a distance of 8 km before the truck was finally stopped by force. According to the DLH KBB report, the caustic soda caused damage to vehicles, injuries to drivers, and corrosive reactions to the metal and clothing of residents passing by.

Administrative requirements such as official permits and driver certification, as well as technical requirements such as vehicle roadworthiness and compliance with official

[39] Peraturan Menteri Perhubungan Republik Indonesia Nomor 60 Tahun 2019 tentang Penyelenggaraan Angkutan Bahan Berbahaya dengan Kendaraan Bermotor di Jalan, Pasal 45 huruf f.

[40] Peraturan Menteri Perhubungan Republik Indonesia Nomor 60 Tahun 2019 tentang Penyelenggaraan Angkutan Bahan Berbahaya dengan Kendaraan Bermotor di Jalan, Pasal 12 huruf b dan f.

distribution channels, have proven to be important factors in preventing incidents. The absence of transport documents such as Material Safety Data Sheets (MSDS), special B3 road permits, and hazard symbols on vehicles indicates a lack of minimum compliance with regulations. However, these documents must be possessed and presented during inspections by relevant agencies to support the emergency response process in the event of an accident.

This case study reveals weak coordination between sectors and supervision in the field. The DLH KBB acknowledged that at the time of the incident, the locus could not be immediately secured due to rain, heavy traffic, and the vastness of the affected area. As a result, sampling was conducted randomly and the domino effect was observed more from the damage reported by residents and motorists. This shows that the rapid response and evidence preservation system at the scene of the incident was not optimal, thereby weakening environmental law enforcement in the chemical transportation sector. Legally, there were violations of the provisions of Chapter VII of Government Regulation No. 74 of 2001, specifically Articles 28 and 29, which require that the supervision of hazardous waste management be carried out by the competent authorities and accompanied by a letter of assignment and identification. The inability of supervisors in the field to immediately secure the location and organize structured sampling demonstrates the weak implementation of these provisions.[41]

Legal responsibility in the transportation of hazardous materials lies not only with the transport company, but also with the individuals directly involved. This is in line with Article 45 letter f of Minister of Transportation Regulation No. 60 of 2019, which requires companies to ensure that all personnel handling hazardous materials have official certification, so that responsibility is not only administrative, but also lies with the competence of the individual.[42] If a violation occurs that causes environmental pollution or loss of life, the perpetrator may be subject to administrative or criminal sanctions. In accordance with Article 76 of Law No. 32 of 2009, administrative sanctions may be imposed on business actors who do not fulfill their environmental management obligations.[43] Furthermore, Article 116 of Law No. 32 of 2009 explains that if an environmental crime is committed by or on behalf of a business entity, criminal sanctions shall be imposed on the business entity and/or the party who gave the order or acted as the leader of the activity. In addition, if the violation is committed by an individual within the scope of the business entity's work, sanctions are still imposed on the person who gave the order or the leader, regardless of whether the action was committed alone or jointly.[44] This provision confirms that B3's legal responsibility attaches to both the company and the individuals directly involved.

[41] Peraturan Pemerintah Republik Indonesia Nomor 74 Tahun 2001 tentang Pengelolaan Bahan Berbahaya dan Beracun, Bab VII tentang Pengawasan dan Penegakan Hukum, Pasal 28–29.
[42] Peraturan Menteri Perhubungan Republik Indonesia Nomor 60 Tahun 2019 tentang Penyelenggaraan Angkutan Bahan Berbahaya dengan Kendaraan Bermotor di Jalan, Pasal 45 huruf f.
[43] Undang-Undang Republik Indonesia Nomor 32 Tahun 2009 tentang Perlindungan dan Pengelolaan Lingkungan Hidup, Pasal 76.
[44] Undang-Undang Republik Indonesia Nomor 32 Tahun 2009 tentang Perlindungan dan Pengelolaan Lingkungan Hidup, Pasal 116.

This mapping of legal responsibilities clearly shows the need for a comprehensive and integrated approach in the B3 transportation system. The comprehensive nature is evident from the various disciplines and sectoral regulations that must be complied with, while the integrated nature requires solid inter-sectoral coordination. Integration between the environmental sector (as the regulator of hazardous materials), the transportation sector (as the technical regulator of vehicles), and the police sector (as the law enforcer on the roads) is absolutely necessary. However, in the case of CV. Yasindo, this integration was not apparent. The comprehensiveness of the existing regulations became meaningless when it was not accompanied by effective integration and coordination at the field level between the relevant ministries/institutions. It was this failure of coordination that created loopholes for business actors to transport hazardous materials illegally.

One important technical aspect in the transportation of Hazardous and Toxic Materials (B3) is preparedness for potential incidents such as liquid spills or leaks during transit. According to the Emergency Response Guidebook (ERG) 2024 Edition, liquid spills must be controlled quickly and systematically to prevent wider impacts on the environment and public safety. Although this ERG is not an official guideline applicable in Indonesia, this document can be used as a reference for developing emergency response procedures in line with the national context. Recommended initial actions include damming, diking, and absorbing using safe inert materials such as sand, clay, vermiculite, or synthetic materials such as polypropylene. The selection of absorbent materials must be done carefully, taking into account the possibility of hazardous chemical reactions between the absorbent material and the spilled substance.[45]

Every B3 transporter must have an emergency response Standard Operating Procedure (SOP) that not only describes these technical steps, but also includes the provision of warning signs, the readiness of fire extinguishers in vehicles, and an incident reporting system to agencies such as the Environmental Agency, fire department, and police. In addition, transport crews must be trained regularly through scenario-based incident simulations, such as corrosive material leaks, chemical reaction explosions, and toxic substance spills that endanger the community around the incident location.

Normatively, the legal procedures for transporting hazardous materials in Indonesia have been comprehensively designed with an emphasis on prevention, preparedness, and law enforcement. However, without strict supervision, firm sanctions, and commitment from business actors, these regulations will end up as formal documents that fail to protect the environment and public safety. Therefore, harmonization between regulation and implementation is key to building a safe, responsible, and sustainable B3 transportation system.

3.3. Environmental and Social Risk Analysis

Spills of chemicals such as liquid sodium hydroxide (sodium hydroxide) on land transport

[45] U.S. Department of Transportation (DOT), Pipeline and Hazardous Materials Safety Administration (PHMSA), 2024, *Emergency Response Guidebook 2024*, Washington, D.C.: U.S. Government Publishing Office, hlm. 355.

routes are not only a technical problem, but also have the potential to cause very serious environmental and social risks. Sodium hydroxide is a strong alkali compound with a very high pH level that is corrosive and reactive when in direct contact with living tissue, water, or soil. Dry weather conditions further increase the potential for harm due to the absence of natural neutralization through rainwater dilution. Direct exposure to this substance can cause chemical burns to human and animal skin, damage vegetation around the site of the incident, and accelerate the degradation of the microenvironment at the spill site.

According to the Emergency Response Guidebook (ERG) 2024 Edition, chemicals that react with water can generate significant heat and even release hazardous gases. In addition, runoff from improperly handled reactive liquids can contaminate nearby water bodies and cause environmental damage.[46] The heat released from this exothermic reaction accelerates the formation of a concentrated alkaline solution that is highly aggressive to organic tissue, whether human, animal, or plant. Without prompt and proper technical handling, this substance has the potential to spread through road drainage systems, damaging infrastructure due to corrosion, and triggering a chain reaction on the aquatic flora and fauna around the site of the incident. Thus, the danger of sodium hydroxide spills is not only local in nature, but can develop into an environmental crisis if not handled quickly, systematically, and in accordance with risk-based emergency protocols.

Toxicologically, sodium hydroxide is classified as a substance that has a high irritant and corrosive effect on the respiratory system, skin, and digestive tract.[47] Sodium hydroxide mist can cause irritation of the upper respiratory tract, coughing, and even pulmonary edema at high exposure levels. Meanwhile, skin and eye contact can cause tissue necrosis.[48] Long-term environmental impacts are also taken into account, as the water solubility of sodium hydroxide allows it to enter the soil and then seep into groundwater.

Furthermore, highly mobile chemicals can significantly affect groundwater quality, and if they seep into irrigation systems or drinking water, they can pose health risks to humans.[49] With chemical transportation systems still passing through densely populated areas, sodium hydroxide spills have significant systemic potential, especially if incidents occur repeatedly. Repeated incidents in the management and transportation of chemical waste along the same route can increase the probability of systemic failures that have a widespread impact on public health and safety.[50] Weak supervision and documentation of hazardous waste also increases

[46] U.S. Department of Transportation (DOT), Pipeline and Hazardous Materials Safety Administration (PHMSA), 2024, *Emergency Response Guidebook 2024*, Washington, D.C.: U.S. Government Publishing Office, hlm. 204-205.
[47] F. Yusuf et al., "Gastrointestinal Mucosal Damages Caused by Ingestion of Corrosive Substances: A Case Study of Hydrochloric Acid and Sodium Hydroxide," *Narra J* 3, no. 3 (2023): e259, https://doi.org/10.52225/narra.v3i3.259.
[48] Eni Mahawati et al., *Keselamatan Kerja Dan Kesehatan Lingkungan Industri* (Semarang: Penerbit Yayasan Kita Menulis, 2021).
[49] F. Chen et al., "Groundwater Quality and Potential Human Health Risk Assessment for Drinking and Irrigation Purposes: A Case Study in the Semiarid Region of North China," *Water* 13, no. 6 (2021): 783, https://doi.org/10.3390/w13060783.
[50] T. A. Hendriana and M. A Mardyanto, "Kajian Risiko Lingkungan Pada Pengelolaan Bahan Berbahaya Dan Beracun (B3) Dan Limbah B3 Industri Kimia Di PT XYZ Dengan Metode Failure Mode and Effect Analysis (FMEA)," *Jurnal Teknik ITS* 12, no. 3 (2023): 142–49, https://doi.org/10.12962/j23373539.v12i3.121683.

the potential for repeated and uncontrollable environmental incidents.[51]

Soil damage caused by exposure to sodium hydroxide is not only physical and chemical in nature, but also disrupts the soil microbial ecosystem and the soil's water absorption capacity. If left unchecked, contaminated areas will experience a decline in ecological quality and function. Therefore, the process of restoring land contaminated with chemicals such as sodium hydroxide has been technically regulated in the Minister of Environment and Forestry Regulation No. P.101/Menlhk/Setjen/Kum.1/11/2018, specifically in Articles 4 to 7, which regulate the polluter's responsibility to carry out remediation, location identification procedures, contamination analysis, and technical remediation measures.[52]

However, based on field investigations conducted by DLH KBB together with a team from the Ministry of Environment one week after the incident, no indications of permanent contamination were found in the soil, water, or air. According to DLH KBB, this was due to rainfall during the incident, which naturally helped neutralize the alkaline properties of caustic soda through reactions with rainwater and acidic soil along the spill route.[53] These findings indicate that the environmental impact in this case tended to be ecologically limited in the short term. However, the mitigation that occurred was passive, dependent on natural factors, rather than the result of a proactively designed technical system. The dependence on weather conditions in the B3 transportation process clearly shows a major gap in the environmental risk management system, which should prioritize planning-based anticipation.

On the contrary, the social impact of this leak is real, widespread, and directly felt by the community.[54] The DLH KBB recorded that at least 100 residents suffered minor injuries to skin irritation, and more than 250 vehicles were damaged, including paint corrosion and holes in clothing due to contact with sodium hydroxide. Road users passing by at the time of the incident did not receive any early warning information or traffic diversion. No evacuation protocol was implemented, and the emergency response was carried out entirely by the West Bandung Regency Fire Department through spraying water and soap, without the support of a standard emergency coordination system. The situation highlights serious weaknesses in social risk management in terms of preparedness, risk communication, and the responsibility of business actors to protect the public. Not only did this incident cause physical and material damage, it also worsened public perception of the safety of chemical transport and reduced public confidence in the government's ability to ensure public safety.

Thus, although the long-term environmental impact in this case was minimized by weather conditions[55], this cannot be used as a measure of risk management success. The social risks that have arisen actually indicate systemic failures in supervision, mitigation, and public

[51] Vikrisius Edwerga, Djusdil Akrim, and Jumadil Jumadil, "Studi Pengelolaan Limbah Bahan Berbahaya Dan Beracun (B3) Di PT ANTAM Tbk," *JEBE: Journal of Environtment Behavior and Engineering* 2, no. 2 (2024): 28–41, https://doi.org/10.56326/jebe.v2i2.5521.

[52] Pasal 4-7 Peraturan Menteri Lingkungan Hidup dan Kehutanan Nomor P.101/Menlhk/Setjen/Kum.1/11/2018 tentang Pedoman Pengelolaan Limbah Bahan Berbahaya dan Beracun (B3).

[53] Wawancara dengan Adhi Setyowibowo, Pejabat Pengawas Lingkungan Hidup Ahli Muda, [22 Mei 2025].

[54] Ibid.

[55] Wawancara dengan Adhi Setyowibowo, Pejabat Pengawas Lingkungan Hidup Ahli Muda, [22 Mei 2025].

education. The social impacts that have arisen cannot be resolved through compensation for losses alone. A comprehensive reform is needed in the licensing system, the management of hazardous material transportation, the development of clear emergency SOPs, as well as the enhancement of institutional capacity and community involvement so that the principle of prudence is not merely a slogan, but is actually implemented.

3.4. Legal Responsibility in the Hazardous Waste Transportation System

The effectiveness of the hazardous waste transportation system depends not only on comprehensive regulations, but also on the clear and proportional enforcement of legal responsibilities for each stakeholder. Based on an analysis of the legal framework and case studies of sodium hydroxide leaks, these responsibilities can be mapped to several parties.

First, the government's responsibility as a regulator and law enforcer. This obligation is multi-faceted, including preemptive measures such as providing transparent information and implementing education as stipulated in Articles 63 and 70 of Law No. 32 of 2009[56], Preventive measures through integrated cross-sectoral supervision (Environment, Transportation, Industry), as well as repressive measures by imposing strict administrative sanctions and prosecuting criminal law enforcement under Articles 76 and 116 of Law No. 32 of 2009.[57] In this case study, the failure of this subsystem was evident in the weak coordination of supervision and the absence of deterrent sanctions prior to the incident, which essentially constituted a form of state negligence in fulfilling the rights of the community.

Second, the responsibility of business actors, both as transporters and producers of hazardous waste, is heavy and comprehensive. Companies are subject to the principle of strict liability as stipulated in Article 88 of Law No. 32 of 2009, which requires them to compensate for losses without the need to prove fault.[58] This responsibility is reinforced by the obligation to comply with all aspects of compliance, such as obtaining all necessary permits and ensuring vehicle roadworthiness (Article 13 of Government Regulation No. 74 of 2001)[59], and training and certifying all personnel. CV. Yasindo Multi Pratama has been proven to violate all of these aspects by not having a license, using vehicles that do not meet the requirements, and employing uncertified drivers.

Third, individual responsibility, namely that of the driver and technical supervisor, is personal and criminal in nature. Drivers personally have a competency obligation to hold certification and implement safety procedures (Article 45 letter f of Permenhub No. 60 of 2019).[60] In this case, the driver of CV. Yasindo was not only uncertified, but also made a high-

[56] Undang-Undang Republik Indonesia Nomor 32 Tahun 2009 tentang Perlindungan dan Pengelolaan Lingkungan Hidup, Pasal 63 dan Pasal 70.
[57] Undang-Undang Republik Indonesia Nomor 32 Tahun 2009 tentang Perlindungan dan Pengelolaan Lingkungan Hidup, Pasal 76 dan Pasal 116.
[58]Undang-Undang Republik Indonesia Nomor 32 Tahun 2009 tentang Perlindungan dan Pengelolaan Lingkungan Hidup, Pasal 88.
[59] Pasal 13 ayat (1) Peraturan Pemerintah Nomor 74 Tahun 2001 tentang Pengelolaan Bahan Berbahaya dan Beracun (B3).
[60] Peraturan Menteri Perhubungan Republik Indonesia Nomor 60 Tahun 2019 tentang Penyelenggaraan Angkutan Bahan Berbahaya dengan Kendaraan Bermotor di Jalan, Pasal 45 huruf f.

risk decision by choosing the regular route, which exacerbated the impact of the incident.

Fourth, the community has the right and role as supervisors and affected parties. These community rights are hierarchical, starting with the right to environmental information (Article 65 of Law No. 32 of 2009)[61], the right to participate and report as a form of preventive oversight (Article 66 of Law No. 32 of 2009)[62], including the right to justice through class action lawsuits or lawsuits against government negligence (legal standing) (Articles 90 and 91 of Law No. 32 of 2009)[63]. However, in the case of sodium hydroxide leakage, the lack of adequate access to information prevented the public from exercising their supervisory role early on, and they could only seek compensation after the damage had been done.

From this mapping, it is clear that the primary responsibility lies with the business actor based on the principle of strict liability. However, ultimate accountability remains with the government as the holder of the mandate to protect the public. In other words, companies are directly responsible for the safety of their operations, while the government is responsible for ensuring that companies fulfill their obligations.

4. CONCLUSION

This study shows that although regulations on the transportation of hazardous and toxic materials (B3) in Indonesia have been comprehensively formulated, their effectiveness has not been optimal in directing transportation practices in accordance with safe and responsible procedures. Low compliance among business actors, weak cross-sectoral supervision, and the ineffectiveness of preemptive measures as a foundation for building legal awareness have resulted in the principle of prudence not being implemented concretely in every stage of B3 transportation. The case of sodium hydroxide leakage by CV. Yasindo Multi Pratama illustrates this systemic failure, with violations covering administrative, technical, and operational aspects, and showing that legal responsibility in this system is multi-layered, where business actors bear primary responsibility based on the principle of strict liability, the government holds the highest accountability in protecting the public, and drivers and technical supervisors can be held individually accountable. Based on these findings, this study emphasizes the need to strengthen the application of the principle of prudence through a tiered and prospective approach, including strengthening preemptive measures through education and information provision, as well as preventive measures through consistent licensing verification and technical supervision, so that regulations do not stop at the normative level but actually function to protect the public and the environment in the transportation of hazardous materials.

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[61] Undang-Undang Republik Indonesia Nomor 32 Tahun 2009 tentang Perlindungan dan Pengelolaan Lingkungan Hidup, Pasal 65.
[62] Undang-Undang Republik Indonesia Nomor 32 Tahun 2009 tentang Perlindungan dan Pengelolaan Lingkungan Hidup, Pasal 66.
[63] Undang-Undang Republik Indonesia Nomor 32 Tahun 2009 tentang Perlindungan dan Pengelolaan Lingkungan Hidup, Pasal 90 dan Pasal 91.

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REFERENCES

Alexander, Hilda B. "SBI Ikut Pulihkan Lahan Tercemar Limbah B3 Di Indonesia." Kompas (Lestari), 2023. https://lestari.kompas.com/read/2023/09/19/060000886/sbi-ikut-pulihkan-lahan-tercemar-limbah-b3-di-indonesia.

Axon, S. "Unveiling Understandings of the Rio Declaration's Sustainability Principles: A Case of Alternative Concepts, Misaligned (Dis)Connections, and Terminological Evolution." *Sustainability* 16, no. 6 (2024): 2600. https://doi.org/10.3390/su16062600.

Budiartha, I Nyoman, and Mohammad Ervin Ardani. "Konsep Hukum Pengelolaan Limbah Berbahaya Dan Beracun (B3) Dalam Perspektif Hukum Lingkungan." *Kertha Wicara: Journal Ilmu Hukum* 12, no. 4 (2025): 432–443. https://ojs.unud.ac.id/index.php/kerthawicara/article/view/104136.

Cahyani, F. A., and A. W. Anditya. "Implementation of Precautionary Principles in Environmental Impact Assessment (EIA) in Indonesia." *Unifikasi: Jurnal Ilmu Hukum* 11, no. 1 (2024): 40–45. https://doi.org/10.25134/unifikasi.v11i01.765.

Chen, F., L. Yao, G. Mei, Y. Shang, F. Xiong, and Z Ding. "Groundwater Quality and Potential Human Health Risk Assessment for Drinking and Irrigation Purposes: A Case Study in the Semiarid Region of North China." *Water* 13, no. 6 (2021): 783. https://doi.org/10.3390/w13060783.

Crowl, Daniel A., and Joseph F. Louvar. *Chemical Process Safety: Fundamentals with Applications*. Edition 4. Boston: Pearson Education, 2019.

Drivdal, L., and J. P. van der Sluijs. "Pollinator Conservation Requires a Stronger and Broader Application of the Precautionary Principle." *Current Opinion in Insect Science* 46 (2021): 95–105. https://doi.org/10.1016/J.COIS.2021.04.005.

Edwerga, Vikrisius, Djusdil Akrim, and Jumadil Jumadil. "Studi Pengelolaan Limbah Bahan Berbahaya Dan Beracun (B3) Di PT ANTAM Tbk." *JEBE: Journal of Environtment Behavior and Engineering* 2, no. 2 (2024): 28–41. https://doi.org/10.56326/jebe.v2i2.5521.

"Egyptian Process Safety Management Steering Committee (PSMSC Egypt) Dan PSM Technical Subcommittee (PSMTC)." *Inherently Safer Design (ISD) Guideline: EGPC-PSM-GL-003*. Cairo, 2022.

Gholamizadeh, Kamran, Chia Rostami, Esmaeil Zarei, Mohammad Yazdi, and Sarbast Moslem. "Advancing Hazardous Materials Transport Safety: Systematic Insights on Risks, Challenges, and Research Gaps." *Journal of Safety Science and Resilience* 7, no. 1 (2024): 100226. https://doi.org/10.1016/j.jnlssr.2025.100226.

Handayani, I. G. A. K. R., C. Yosiana, and S Kongrawd. "Reform of Environmental Approval Policy for Renewable Energy in Indonesia." *Journal of Sustainable Development and*

Regulatory Issues 3, no. 2 (2025): 286–323. https://doi.org/10.53955/jsderi.v3i2.101.

Hendriana, T. A., and M. A Mardyanto. "Kajian Risiko Lingkungan Pada Pengelolaan Bahan Berbahaya Dan Beracun (B3) Dan Limbah B3 Industri Kimia Di PT XYZ Dengan Metode Failure Mode and Effect Analysis (FMEA)." *Jurnal Teknik ITS* 12, no. 3 (2023): 142–49. https://doi.org/10.12962/j23373539.v12i3.121683.

Hutabarat, Emi Septiana. "Analisa Potensi Risiko Keselamatan Pengemudi Barang Bahan Berbahaya Dan Beracun Berdasarkan Agreement for Transport of Dangerous Goods by Road (ADR)." *Jurnal Penelitian Transportasi Darat* 21, no. 2 (2019): 125–30. https://doi.org/10.25104/jptd.v21i2.1564.

Huzaini, F. N., U. Risvano, A. T. Suprapto, and S. Martinez. "Enterprise Risk Management in Hazardous Waste Processing for Industrial Environmental Safety." *2025 4th International Conference on Creative Communication and Innovative Technology (ICCIT)*, 2025, 1–7. https//doi.org/10.1109/ICCIT65724.2025.11167745.

Imran, Babar, Sher Jamal Khan, Ishtiaq A. Qazi, and Muhammad Arshad. "Removal and Recovery of Sodium Hydroxide (NaOH) from Industrial Wastewater by Two-Stage Diffusion Dialysis (DD) and Electrodialysis (ED) Processes." *Desalination and Water Treatment* 57, no. 17 (2016): 7926–32. https://doi.org/10.1080/19443994.2015.1048742.

Khan, Faisal. *Methods in Chemical Process Safety*. Edition 20. Amsterdam: Academic Press (Elsevier)., 2017.

Liu, L., J. Li, L. Zhou, T. Fan, and S. Li. "Research on Route Optimization of Hazardous Materials Transportation Considering Risk Equity." *Sustainability* 13, no. 16 (2021): 9427. https://doi.org/10.3390/su13169427.

Mahawati, Eni, Qurnia Fitriyatinur, Cici Apriza Yanti, Puspita Puji Rahayu, and Cici Aprilliani. *Keselamatan Kerja Dan Kesehatan Lingkungan Industri*. Semarang: Penerbit Yayasan Kita Menulis, 2021.

Maulana, Irvan. "2 Pegawai Pabrik Jadi Tersangka Kebocoran Gas Caustic Soda Karawang." detikJabar, 2024. https://www.detik.com/jabar/berita/d-7178673/2-pegawai-pabrik-jadi-tersangka-kebocoran-gas-caustic-soda-karawang.

Panuntun, Bagus Puji, and Reni Susanti. "DLH Ungkap Cairan Kimia Yang Banjiri Jalan Di Bandung Barat: Soda Api." Kompas (Bandung), 2024. https://bandung.kompas.com/read/2024/12/24/122527778/dlh-ungkap-cairan-kimia-yang-banjiri-jalan-di-bandung-barat-soda-api.

Kementerian Ketenagakerjaan Republik Indonesia. *Program Keselamatan dan Kesehatan Kerja Nasional Indonesia 2024–2029*. Jakarta: Kementerian Ketenagakerjaan RI.

Proyogo, Joshua Wijaya. "Balancing Risk and Caution: The Precautionary Principle in Indonesian Environmental Law Context." *Universitas Negeri Semarang in Indonesian Journal of Environmental Law and Sustainable Development* 3, no. 1 (2024). https://doi.org/10.15294/ijel.v3i1.7889.

Putra, Muhammad Kresna Adi, and Yun Yun. "Analisis Pengelolaan Limbah B3 Pada Proses Pengangkutan Dalam Rangka Efesiensi Pada PT Pratama Karya Nugraha." *Jurnal*

Lentera Bisnis 14, no. 3 (2025): 3398–99. https://doi.org/10.34127/jrlab.v14i3.1741.

Rizvanli, S., and B. Shahpalangova. "Assessment of the Hazard Risk That May Arise During the Transportation of Hazardous Chemicals by Vehicle Transport." *Təbiət və Elm* 6, no. 8 (2024): 23–37. https://doi.org/10.36719/2707-1146/47/23-37.

Sachdeva, Karan Raj. "Balancing Progress and Protection: The Precautionary Principle in Global Environmental Governance." *International Journal For Multidisciplinary Research* 6, no. 5 (2024). https://doi.org/10.36948/ijfmr.2024.v06i05.28227.

Shi, J., T. Long, L. Zheng, S. Gao, and L Wang. "Neutralization of Industrial Alkali-Contaminated Soil by Different Agents: Effects and Environmental Impact." *Sustainability* 14, no. 10 (2022): 5850. https://doi.org/10.3390/su14105850.

Tropenauer, B., D. Klinar, and J Golob. "Improved Understanding of Sodium Hydroxide Concentration Role and Kinetic Model of Cryolite Reactive Extraction in Cathode Spent Pot Linings." *Polish Journal of Chemical Technology* 23, no. 1 (2021): 37–44. https://doi.org/10.2478/pjct-2021-0006.

U.S. Department of Transportation (DOT), Pipeline and Hazardous Materials Safety Administration (PHMSA), 2024, Emergency Response Guidebook 2024, Washington, D.C.: U.S. Government Publishing Office

Yang, Y. "The Application and Reflection of Cradle to Cradle in Industrial Design." *Academic Journal of Science and Technology* 9, no. 2 (2024): 221–23. https://doi.org/10.54097/39gtam48.

Yusuf, F., A. Abubakar, D. Maghfirah, M. Heltomi, and C. C Isitua. "Gastrointestinal Mucosal Damages Caused by Ingestion of Corrosive Substances: A Case Study of Hydrochloric Acid and Sodium Hydroxide." *Narra J* 3, no. 3 (2023): e259. https://doi.org/10.52225/narra.v3i3.259.

Zhang, W., W. Cheng, and W. Gai. "Hazardous Chemicals Road Transportation Accidents and The Corresponding Evacuation Events from 2012 to 2020 in China: A Review." *International Journal of Environmental Research and Public Health* 19, no. 22 (2022): 15182. https://doi.org/10.3390/ijerph192215182.