



Risk Analysis of Solid, Liquid, and B3 Waste Management Using the Failure Mode and Effect Analysis (FMEA) Method at PT Natural Indococonut Organik

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Abstract: Effective industrial waste management is essential for operational continuity and environmental protection. This case study analyzes solid, liquid, and Hazardous and Toxic Materials (B3) waste management at PT Natural Indococonut Organik (PT NICO) and prioritizes operational risks using the Failure Mode and Effects Analysis (FMEA) method. Data were collected in 2025 through site observation, semi-structured interviews with operational staff, and review of company documents (UKL-UPL and operational records). Waste generation volumes were quantified and potential failure modes were identified, then scored for Severity (S), Occurrence (O), and Detection (D) to calculate Risk Priority Numbers (RPN). Results show liquid waste is the largest stream ($\approx 3,328$ L/day) and that the highest-priority risks are liquid waste leakage/seepage ($RPN = 112$) and improper B3 storage ($RPN = 96$); lower-priority risks included irregular waste recording and solid waste accumulation. While current management practices (sorting, reuse, closed piping to infiltration wells, and TPSL-B3) are generally adequate, targeted improvements are recommended: strengthen monitoring and recording systems, implement leak-prevention and secondary containment measures, and enhance B3 handling procedures. Future studies should combine FMEA with laboratory waste characterization to refine risk controls.

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Introduction

The coconut processing industry is an agro-industrial sector that plays a vital role in the

economy, particularly in North Halmahera Regency. PT Natural Indococonut Organik (PT NICO), a coconut processing company, produces various types of waste from production, office, and support activities, requiring proper management to maintain operational and environmental sustainability (PT NICO, 2025).

Based on 2025 data, PT NICO's operational activities generated solid waste, liquid waste, and hazardous waste. This waste has been managed through sorting, reuse, a sanitary landfill system, and special handling for hazardous waste. Furthermore, some coconut processing waste is reused as a form of waste management that supports operational efficiency (PT NICO, 2025).

Even if a waste management system has been implemented, evaluation is still necessary to ensure its effectiveness in accordance with good environmental management principles. Suboptimal management has the potential to cause environmental pollution, harm health, and impact the smooth operation of the company, therefore, an analysis of the existing waste management situation is necessary.

Furthermore, the waste management process still carries various potential risks, such as waste accumulation, liquid waste leaks, incorrect storage of hazardous and hazardous waste, and irregular recording and monitoring. Therefore, a risk analysis using the Failure Mode and Effect Analysis (FMEA) method is required to prioritize risks requiring control.

This study aims to identify the types and sources of waste, describe the waste management system, and analyze the level of waste management risk using the Failure Mode and Effect Analysis (FMEA) method at PT Natural Indococonut Organik (PT NICO). This study is important as a basis for waste management evaluation, with the novelty of applying the FMEA method in determining waste management risk priorities based on operational data for 2025.

Research Methods

This research uses a descriptive method with a case study approach at PT Natural Indococonut Organik (PT NICO), North Halmahera Regency. The research focuses on the management of solid waste, liquid waste, and Hazardous and Toxic Materials (B3) and analyzes their risk levels using the Failure Mode and Effect Analysis (FMEA) method.

Data were collected through observation, interviews, and documentation regarding waste types, waste sources, waste generation, and the company's waste management system. The data were then analyzed descriptively and then analyzed using the Failure Mode and Effect Analysis (FMEA) method. This analysis involved determining Severity, Occurrence, and Detection values, calculating the Risk Priority Number (RPN), and developing improvement proposals using the 5W+1H approach.

The research population includes the entire solid waste, liquid waste, and Hazardous and Toxic Materials (B3) waste management system in the operational activities of PT Natural Indococonut Organik (PT NICO). The research sample consists of data on the types, sources, generation, and waste management systems obtained through observation, interviews, and documentation.

The research began with problem identification and data collection, followed by a descriptive analysis of waste management conditions. A Failure Mode and Effect Analysis (FMEA) was then conducted to identify and prioritize risks based on the Risk Priority Number (RPN), which served as the basis for developing proposed waste management improvements.

Results and Discussion

Solid Waste Management Analysis

Based on the results of research conducted at PT Natural Indococonut Organik (PT NICO), the solid waste generated comes from office activities and employee mess. Based on data obtained from the company's UKL-UPL document, the total domestic waste generated is 22.6 kg/day consisting of organic waste and inorganic waste. The organic waste generated comes from food scraps and easily decomposed materials, while inorganic waste consists of plastic, paper, and metal originating from employee activities. Based on the observation results, the company has provided a Temporary Shelter (TPS) as a means of storing waste before further management.

Solid waste management is carried out by sorting waste by type. Organic waste is processed by burying it, while inorganic waste is collected and reused or distributed to waste banks. This sorting aims to simplify the management process and reduce the amount of waste discharged directly into the environment.

Based on waste management theory, waste sorting is a crucial step in a waste management system because it increases the effectiveness of waste management based on its characteristics. Separating organic and inorganic waste allows for more focused waste management, minimizing the potential for environmental pollution. In general, PT NICO's solid waste management encompasses collection, sorting, temporary storage, and reuse of several types of waste that still have utility. This demonstrates the company's efforts to control the environmental impact of domestic solid waste.

Analysis of liquid waste management

The liquid waste produced by PT NICO comes from clean water used for office operations, employee restrooms, environmental cleaning, and irrigation. According to data, total clean water usage reaches 4,360 liters per day.

This water use produces domestic liquid waste that requires management to prevent negative environmental impacts. Based on observations and the company's Environmental Management and Management Plan (UKL-UPL) documents, the resulting liquid waste is channeled through a closed piping system to an infiltration well.

A closed piping system is used to reduce the risk of leaks and the spread of waste into the surrounding environment. Meanwhile, infiltration wells serve as a means of managing domestic liquid waste before the water seeps into the ground.

Based on the theory of liquid waste management, waste management aims to prevent environmental pollution from uncontrolled waste disposal. Therefore, the use of a closed piping system and infiltration wells demonstrates the company's efforts to reduce the environmental impacts of liquid waste. In general, the liquid waste management system implemented by PT NICO has supported environmental protection efforts by controlling waste disposal routes and providing liquid waste management facilities tailored to the company's needs.

Analysis of B3 waste management

The hazardous and toxic waste (B3) generated by PT NICO originates from generator operations, office activities, and employee messes. Data shows that liquid B3 waste, in the form of used oil, is produced at 4 liters per 3–4 month period. Furthermore, solid B3 waste is produced at 5.05 kg per same period, consisting of oil filters, used oil pans, oil packaging, used batteries, and used light bulbs.

B3 waste has different characteristics from domestic waste because it has the potential to cause negative impacts on the environment and health if not managed properly. Therefore, B3 waste requires special handling according to its characteristics and level of danger. Based on field observations, PT NICO has provided a Temporary B3 Waste Storage Area (TPSL-B3) as a storage

location for B3 waste prior to further management. In addition, based on the company's UKL-UPL document, B3 waste can be stored for a maximum of 365 days before being handed over to a party holding a B3 waste management permit.



Figure 1 Temporary Storage Area for B3 Waste at PT NICO Source: Research Documentation, 2026.

Source: Research Documentation, 2026

Based on the research documentation, it appears that the hazardous waste storage area is equipped with hazardous waste identification labels. The presence of these facilities indicates that the company has separated hazardous waste from other waste to reduce the risk of environmental pollution.

Based on the theory of hazardous waste management, temporary storage in appropriate facilities is one form of risk control for the environment and human health. With the TPSL-B3, companies can manage hazardous waste in a more controlled manner before handing it over to authorized parties (PP No. 22 of 2021). In general, the hazardous waste management system implemented by PT NICO includes temporary storage and handover to authorized parties. This management demonstrates the company's efforts to control the risks posed by hazardous waste, thereby minimizing its negative impact on the environment.

The amount of waste produced

The amount of waste generated is one aspect that needs to be considered in a company's environmental management. Based on operational data from PT Natural Indococonut Organik (PT NICO) in 2025, the waste generated consists of domestic solid waste, liquid waste, and Hazardous and Toxic Materials (B3) waste. This waste volume data is used to provide an overview of the waste generated from the company's operational activities. A summary of the amount of waste generated can be seen in Table 6.1.

Table 1 Amount of waste produced

No	Types of waste	Waste sources	Amount
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1.	Waste	Office and mess	± 22.6 kg/day
	Domestic Density	activities employee	
2.	Liquid waste	Use	± 3,328
		water	liters/day
		clean for operational activities, cleanliness,	
		An	
		d	
		employee needs	
3.	Waste B3 Liquid (Used oil)	Maintenance machine generator	± 4 liters/3–4 month
4.	Solid B3 Waste	Filter oil	± 5 kg/3–4 months
		former, advanced	
		used	
		used oil packaging,	

Source: PT NICO Data, (2025)

Based on Table 1, the waste generated from the operational activities of PT Natural Indococonut Organik (PT NICO) consists of domestic solid waste, liquid waste, and B3 waste. Domestic solid waste originating from office activities and employee messes reaches approximately ±22.6 kg per day. Liquid waste generated from the use of clean water is estimated to reach ±3,328 liters per day. In addition, the B3 waste generated consists of used oil of approximately ±4 liters in a period of 3–4 months and solid B3 waste of approximately ±5 kg in the same period. These data indicate that the company's operational activities produce various types of waste that require management according to the characteristics and amount of waste generated.

Discussion

1. The amount of waste generated

Table 2. Waste generation

Types of waste	Amount of generation	Unit	Information
Waste domestic density	22.6	Kg/day	Managed through sorting An

dreuse				
Liquid waste	3,328	Liters/day	Eruption biggest so that	the become management priorities
Liquid B3 Waste	4	Liter/3-4 months	Needs special handling	
Solid B3 Waste	5	Kg/3-4 months	Needs special storage	

Source: 2026 data processing

Based on Table 2, liquid waste is the type of waste with the largest volume generated by PT NICO, amounting to approximately 3,328 liters per day. This amount is greater than both domestic solid waste (approximately 22.6 kg per day) and hazardous and toxic waste produced by the company. This condition indicates that liquid waste is a top priority in the company's waste management system because it accounts for the largest volume generated.

Meanwhile, domestic solid waste can still be managed through sorting and recycling. The amount of hazardous and toxic waste generated is relatively small, amounting to approximately 4 liters of used oil and approximately 5 kg of solid hazardous and toxic waste over a 3–4 month period. Despite this relatively small amount, hazardous and toxic waste still requires special handling to prevent negative impacts on the environment.

2. Company Environmental Performance

Table 3 Environmental performance of PT. NICO

Management aspects	Condition	Information
Solid Waste Management	Good	Sorting is carried out and utilizationre cycle waste that still has useful value
Liquid waste management	Pretty good	Waste liquid streamed towards the infiltration well through a closed system
B3 waste management	Good	B3 Waste TPS is available for temporary storage
Waste utilization	Good	Coconut water and rejected coconuts are reused
Monitoring and Evaluation	Needs improvement	Recording of waste generation has not been carried out routinely

Source: 2026 data processing

Based on Table 3, PT NICO's environmental performance has generally been good. This is demonstrated by the management of solid, liquid, and hazardous waste, which has been

carried out in accordance with the characteristics of each type of waste. Furthermore, the company has also reused waste that still has utility, thereby reducing the amount of waste discharged into the environment.

However, waste management monitoring and evaluation activities still need to be improved, particularly through regular recording of waste generation. With more structured record-keeping, companies can evaluate the effectiveness of their waste management systems and support sustainable environmental performance improvements.

3. Waste Management Risk Analysis using the FMEA method Waste management risk analysis is carried out using the FMEA method.

Failure Mode and Effect Analysis (FMEA) method to determine the priority level of risks that could potentially occur in the waste management system at PT Natural Indococonut Organik (PT NICO). Based on the results of the Risk Priority Number (RPN) calculation in Table 5.7, four potential risks were obtained that could occur in the company's waste management with different priority levels.

The risk of liquid waste leakage or seepage has the highest RPN value, at 112. This value indicates that the risk of liquid waste leakage is a top priority that requires attention in the company's waste management system. This risk has the potential to cause environmental pollution if liquid waste escapes the established management system. Given that liquid waste is the type of waste with the highest generation compared to other wastes, regular monitoring and supervision are required to ensure the waste management system is running smoothly.

The next risk is improper storage of hazardous waste, with an RPN of 96. Although the amount of hazardous waste produced is relatively small, its characteristics, which can potentially harm the environment and worker health, require special attention. Therefore, hazardous waste storage must be carried out in accordance with applicable procedures and accompanied by regular monitoring.

Furthermore, the risk of not routinely recording waste generation has an RPN value of 60. This risk can hinder the decision-making process related to waste management because the company lacks comprehensively documented data. Accurate data availability is necessary to support ongoing waste management monitoring, evaluation, and control.

The risk of solid waste accumulation has an RPN of 45 and is the lowest priority risk compared to other risks. Nevertheless, solid waste accumulation still requires attention to prevent environmental disturbances and reduce the effectiveness of the company's waste management practices.

Based on the FMEA analysis, the risk of liquid waste leakage and improper storage of hazardous and hazardous waste are priority risks requiring primary attention. From an Industrial Engineering perspective, these results demonstrate the importance of regular monitoring, supervision, and evaluation to enhance the effectiveness of the waste management system and support continuous improvement in the company's operations.

Conclusion and Recommendation

This study shows that PT Natural Indococonut Organik (PT NICO) produces domestic solid waste, liquid waste, and Hazardous and Toxic Materials (B3) waste that has been managed through sorting, reuse, a closed piping system leading to an infiltration well, and temporary storage of B3 waste before being handed over to a licensed party. The results of the analysis using the Failure Mode and Effect Analysis (FMEA) method show that leakage or seepage of liquid waste is the risk with the highest Risk Priority Number (RPN) value so that it becomes the main priority in control, followed by the risk of incorrect storage of B3 waste, the absence of routine waste generation recording, and the accumulation of solid waste. These findings

indicate that in general the waste management system in the company has been running well, but still requires improvement in the aspects of monitoring, evaluation, and recording to support the effectiveness of sustainable waste management.

This research is still limited to the analysis of waste management conditions based on observations, interviews, documentation, and the application of the FMEA method without conducting direct waste quality testing in the laboratory. Therefore, further research is recommended to combine risk analysis with waste quality measurements so that the evaluation results are more comprehensive. Practically, the results of this study can be used as evaluation material for PT Natural Indococonut Organik (PT NICO) in strengthening the monitoring system, improving the accuracy of waste generation recording, conducting regular supervision of liquid waste and B3 waste management, and developing corrective measures based on risk priorities so that waste management can be more effective, efficient, and sustainable.

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