

Redesign of the Temporary Storage Area for Hazardous Waste at PT XYZ

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Abstract

The rapid growth of the manufacturing sector in Indonesia has significantly contributed to the national economy. However, it has also increased the generation of hazardous and toxic waste (B3). The manufacturing industry is one of the major contributors to B3 waste and is therefore required to comply with Government Regulation No. 22 of 2021 and Minister of Environment and Forestry Regulation No. 6 of 2021. PT XYZ, an automotive spare parts manufacturing company located in the Cikarang industrial area, generates B3 waste including contaminated packaging, used oil, coolant, contaminated scrap metal, and anti-rust residue. Preliminary observations indicate that the existing temporary storage facility (TPS) for B3 waste does not fully comply with technical and regulatory requirements. This study aims to redesign the B3 waste temporary storage facility in accordance with applicable regulations and to calculate the required supporting facilities. The methodology includes identifying the types, characteristics, and quantities of waste generated, evaluating existing conditions, and calculating the required number of containers, pallets ventilation openings, lighting units, spill containment capacity, and forklift access lanes. The results indicate a requirement of 97 drums, 13 spill pallets, and a minimum spill containment capacity of 19,206 m³ for a 90-day storage period. The proposed design measures 9.3 m x 9.1 m x 4.5 m and includes adequate ventilation, 9 LED lamps, a 3-meter-wide forklift lane, hazard-based zoning separation, and a compliant drainage system, thereby improving safety and minimizing environmental pollution risks.

Keywords: *hazardous and toxic waste (B3), temporary storage facility design, regulatory compliance, industrial waste management, environmental protection*

Abstrak

Pertumbuhan pesat sektor manufaktur di Indonesia berkontribusi signifikan terhadap perekonomian nasional, namun juga meningkatkan timbulan limbah bahan berbahaya dan beracun (B3). Industri manufaktur menjadi salah satu penyumbang utama limbah B3 sehingga wajib memenuhi ketentuan Peraturan Pemerintah No. 22 Tahun 2021 dan Peraturan Menteri Lingkungan Hidup dan Kehutanan No. 6 Tahun 2021. PT XYZ, perusahaan manufaktur suku cadang otomotif di kawasan industri Cikarang, menghasilkan limbah B3 berupa kemasan terkontaminasi, oli bekas, coolant, scrap metal terkontaminasi, dan residu anti karat. Observasi awal menunjukkan bahwa fasilitas tempat penyimpanan sementara (TPS) limbah B3 belum sepenuhnya memenuhi persyaratan teknis dan regulasi. Penelitian ini bertujuan merancang ulang TPS limbah B3 yang sesuai peraturan serta menghitung kebutuhan fasilitas pendukungnya. Metode yang digunakan meliputi identifikasi jenis, karakteristik, dan kuantitas limbah, evaluasi kondisi eksisting, serta perhitungan tumpahan, dan jalur forklift. Hasil perhitungan menunjukkan kebutuhan 97 drum, 13 spill pallet, dan kapasitas penampungan tumpahan minimum 19,206 m³ untuk periode penyimpanan 90 hari. Desain usulan berukuran 9,3 m x 9,1 m x 4,5 m dengan ventilasi memadai, 9 lampu LED, jalur forklift selebar 3 m, pemisahan zona bahaya, serta sistem drainase sesuai standar, sehingga meningkatkan keselamatan dan meminimalkan risiko pencemaran.

Kata Kunci: *limbah bahan berbahaya dan beracun (B3), desain tempat penyimpanan sementara, kepatuhan regulasi, pengelolaan limbah industri, perlindungan lingkungan*

1. Introduction

The growth of the manufacturing sector in Indonesia has shown a consistently increasing trend and has made a significant contribution to the national economy. However, this industrial development is also accompanied by growing challenges in environmental management, particularly related to the generation of hazardous and toxic waste. The manufacturing sector is one of the main contributors to hazardous waste generation in Indonesia. During the 2020–2024 period, millions of tons of hazardous waste were generated annually from industrial activities, with a significant increase recorded in 2022 compared to previous years

[1]. This situation suggests that industrial operations can pose significant environmental threats if dangerous waste is not handled appropriately. Consequently, it is crucial to establish a robust, quantifiable, and regulation-adherent hazardous waste management framework to reduce environmental contamination and safeguard public health. The handling of harmful and toxic waste within the manufacturing sector must meet the criteria set forth in the Business Activity Standards for the Implementation and Forestry No. 3 of 2021, which pertains to guidelines for Risk-Based Business Licensing in the Environmental and Forestry sector. This directive outlines the technical specifications for managing hazardous and toxic waste, which encompasses the provisional storage of waste at designated temporary storage facilities meant for hazardous and toxic waste [2].

One of the companies operating in the Cikarang industrial area is PT XYZ, a manufacturer of automotive spare parts that generates hazardous and toxic waste as a by-product of its production activities. Hazardous and toxic waste, based on its characteristics and concentration, has the potential to cause negative impacts on the environment and pose risks to human health and other living organisms if not properly managed [3]. In accordance with the applicable laws and regulations, every hazardous and toxic waste generator is required to comply with the technical and administrative requirements related to the provision and operation of hazardous and toxic waste temporary storage [4] Based on preliminary observations at PT XYZ, the existing hazardous and toxic waste temporary storage facilities have not fully met the technical storage requirements stipulated in the prevailing of a ventilation system, limited storage capacity, the lack of hazardous waste labels and symbols, and the absence of spill control facilities such as spill trays or containment basins.

Non-compliance in the management of hazardous and toxic waste is not merely technical in nature but also carries legal implications, as improper management may be classified as a violation of environmental laws and regulations. Such conditions have the potential to increase the risk of environmental pollution, occupational health and safety hazards, and non-compliance with applicable regulatory requirements. Therefore, the evaluation and proper design of hazardous and toxic waste temporary storage facilities in accordance with technical standards and regulatory provisions are essential. The design of a hazardous and toxic waste temporary storage facility should not only fulfil administrative requirements but also ensure environmental protection and occupational safety through the implementation of appropriate technical construction standards and operational management practices. Thus, a compliant design is expected to minimize the risk of environmental pollution and potential occupational health and safety hazards resulting from the uncontrolled release of hazardous waste into the environment [5].

2. Material and Methods

The study begins with the problem identification stage, followed by a literature review to establish the theoretical and regulatory foundation. Subsequently, data collection is carried out, consisting of primary data obtained through field observations and secondary data derived from hazardous waste generation records. The collected data are then analyzed in the data analysis and compliance assessment stage to evaluate existing conditions and determine their compliance with applicable technical standards and regulations. Based on the analysis results, the design of the hazardous and toxic waste temporary storage facility is developed by referring to Government Regulation No. 22 of 2021, Ministerial Regulation No. 6 of 2021, and Ministerial Regulation No. 14 of 2013 as the basis for establishing design criteria. The final stage of this study is the conclusion and recommendation, which summarizes the findings and provides guidance for implementing a compliant and effective hazardous waste storage system (**Fig. 1**).

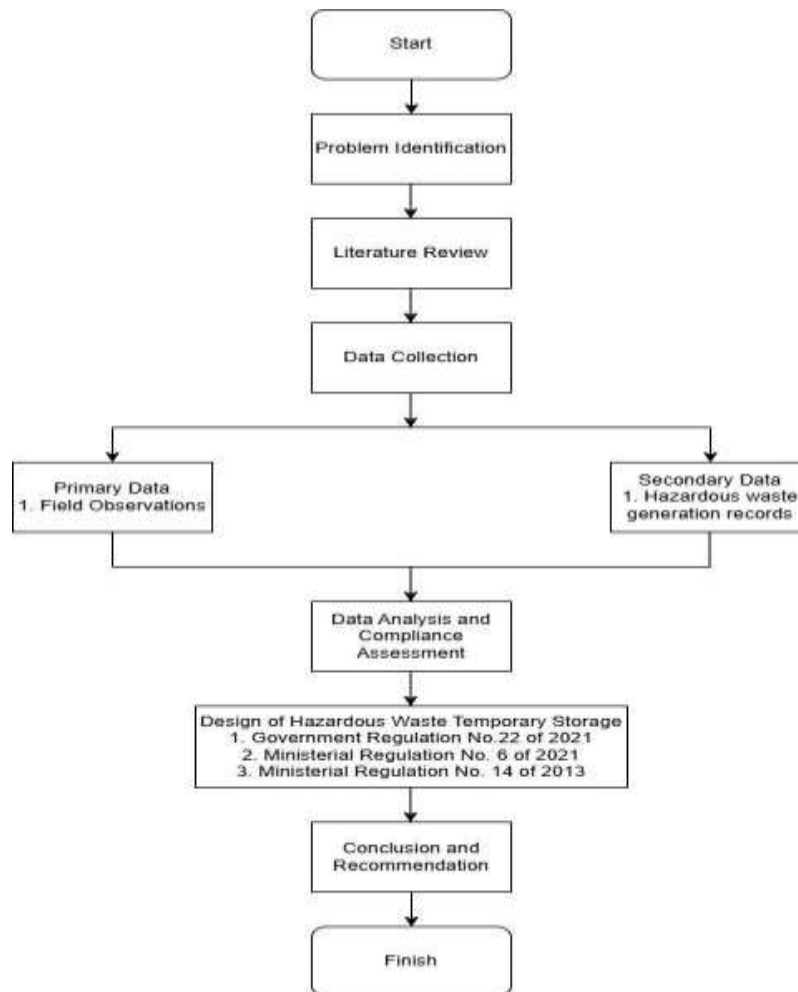


Fig. 1. Framework

3. Results and Discussions

3.1. Identification of Hazardous and Toxic Waste at PT XYZ

The storage duration of hazardous and toxic waste at the hazardous and toxic waste temporary storage is determined based on the daily generation quantity and the waste category. Each type of waste was classified according to its hazardous properties, including toxicity, ignitability, corrosivity, and potential environmental hazards. This classification was conducted to ensure that the storage practices implemented at the hazardous and toxic waste temporary storage comply with applicable environmental regulations. Some of waste originates from non-specific sources and is classified as Category 2, with primary characteristics including environmental hazard and toxicity. Meanwhile, waste such as contaminated scrap metal (A345-2) and residual anti-rust substances (A323-1) falls under specific sources and is classified as Category 1 due to its higher level of hazard, particularly its ignitability.

This identification serves as the basis for determining appropriate storage, packaging, and management methods to ensure that hazardous waste is handled safely and in compliance with the provisions of Government Regulation No. 22 of 2021 **Table 1**.

Table 1. Identification of Hazardous and Toxic Waste

No	Waste Code	Type of Waste	Characteristics	Sources	Category
1	B104d	Hazardous waste- Contaminated drums	Environmentally Hazardous, Toxic	Non- Specific	Category 2
	B104d	Hazardous waste- Anti-rust jerrycans	Environmentally Hazardous, Toxic	Non- Specific	Category 2
2	B110d	Hazardous waste- Contaminated rags and gloves	Environmentally Hazardous, Toxic	Non- Specific	Category 2

No	Waste Code	Type of Waste	Characteristics	Sources	Category
3	A345-2	Hazardous waste-Contaminated scrap metal	Environmental Hazardous, Ignitability	Specific	Category 1
4	B105d	Used oil	Environmentally Hazardous, Toxic	Non- Specific	Category 2
	B105d	Coolant	Environmentally Hazardous, Toxic	Non- Specific	Category 2
5	A323-1	Residual anti-rust substances	Environmentally Hazardous, Ignitability	Specific	Category 1

Source: Hazardous and Toxic Waste Manifest of PT XYZ, 2026

3.2 Evaluation of the Existing Condition of the Hazardous and Toxic Waste Storage Area at PT XYZ

PT XYZ is a manufacturing company operating in Cikarang, Bekasi Regency. The company is engaged in the production of components and spare parts for machinery and turbines, as well as components and accessories for two and three wheeled motorcycles. Its operational activities include machining processes, fabrication, and the assembly of mechanical components that support various industrial sectors.



Fig. 2. Existing Condition of Temporary Storage

Based on field observations, the temporary storage building for hazardous and toxic waste at PT XYZ has dimensions of 2.7 m in length, 2.7 m in width, and 2.1 m in height. In general, the existing condition of the facility does not fully comply with the technical requirements for hazardous waste storage. The building is not equipped with a ventilation system, resulting in inadequate air circulation within the room. In addition, there is no spill containment channel or collection sump to anticipate potential leakage of liquid waste. The lighting system inside the storage area is also not optimal to support proper inspection and monitoring activities. From a storage management perspective, the arrangement of hazardous waste is not in accordance with technical standards, and the waste containers are not equipped with proper hazardous waste labels and symbols as required by applicable regulations [6]. These conditions may increase the risk occupational hazards and environmental pollution if corrective measures are not implemented.

The main building area of the company is marked with a blue outline, while the position of the hazardous and toxic waste temporary storage area is indicated by the pink colored section located along the side of the building. It can be observed that the storage location is situated at the edge of the production area and is adjacent to the company's internal access road. This marking provides an overview of the relative position of the hazardous waste storage facility in relation to the production building and the surrounding infrastructure **Fig 3**.



Fig. 3. Location of Temporary Storage

3.3 Determination of Required Packaging Units for Hazardous and Toxic Waste

In this hazardous and toxic waste management planning, all types of waste are scheduled to be transported periodically every three months (90 days). The establishment of this uniform transportation period is intended to simplify the operational system and improve efficiency in waste management within the temporary storage facility. It also reduces environmental risks, such as leakage and spillage, enhances occupational health and safety by minimizing the duration of hazardous waste storage on site, facilitates operational control, and optimizes storage capacity. Although certain types of waste are permitted by regulations to be stored for up to 365 days, the implementation of a 90 days transportation period is selected as a preventive measure to improve the safety and efficiency of the hazardous waste management system **Table 2.**

Table 2. Required Packaging PT XYZ

No	Waste Code	Type of Waste	Quantity (L/3 months)	Packaging (Drums/L)	Number of Drums	Storage Period (Days)
1	B104d	Hazardous waste-contaminated drums	6000	200	30	90
		Anti-rust jerrycans	4000	200	20	365
2	B110d	Hazardous waste-contaminated rags and gloves	1400	200	7	365
3	A345-2	Hazardous waste-contaminated scrap metal	5333	200	27	365
4	B105d	Used oil	320	200	2	365
		Coolant	134	200	1	365
5	A323-1	Residual anti-rush substances	6,7	200	1	90
			Total Drums: 88			
			Reserve 10% : 9			

Source: Calculation Result, 2026

The total of 200 liter drums used to store hazardous and toxic waste is 88 drums. In addition, 9 drums are provided as reserve and will be stored in the warehouse to optimize the available space in the hazardous and toxic waste storage area.

3.4 Calculation of the Required Number of Pallets

The pallet used in this design is a spill pallet with dimensions of 1100 mm x 1100 mm, designed to support safe and efficient waste storage.



Fig 4. Pallet dimensions of 1100 mm x 1100 mm
 Source: Rajapallet

The required number of pallets was determined based on the quantity of hazardous and toxic waste packaging generated, as well as the storage capacity of each pallet. Each type of waste was grouped according to its hazardous characteristics to ensure proper storage management and compliance with hazardous waste storage requirements. The total number of generated hazardous and toxic waste drums is 97 units, consisting of 60 drums classified as toxic and 28 drums classified as ignitable. To anticipate additional requirements, a 10% reserve was added to each waste category. For waste with toxic characteristics, the number of drums increased to 66 units after adding the reserve. By applying a two-layer stacking system, the effective number of drums becomes 33 units. Given that each pallet can accommodate 4 drums, the required number of pallets is 9 units.

Meanwhile, for waste with ignitable characteristics, the number of drums increased to 31 units after adding the reserve. With the same two-layer stacking system, the effective number of drums becomes 16 units. With a capacity of 4 drums per pallet, the required number of pallets is 4 units. Therefore, the total number of pallets required for storing hazardous and toxic waste drums is 13 units.

3.5 Measurement of Spill Container

A spill container is a containment facility provided in hazardous and toxic waste storage areas to hold waste spills that may occur due to leakage, container damage, or accidents during the storage process. In addition to containing spilled waste, a spill container also functions to collect water used during the cleaning process after an incident. The presence of a spill container aims to prevent the waste from spreading into the surrounding environment and to reduce the risk of soil water contamination.

$$\begin{aligned} \text{Total Volume} &= \text{Maximal Drum Volume (m}^3\text{)} \times \text{Total Drum} \\ \text{Total Volume} &= 0,18 \text{ m}^3 \times 97 = 17,46 \text{ m}^3 \end{aligned}$$

$$\begin{aligned} \text{Minimum Spill Container Volume} &= \text{Total Volume} \times 110\% \\ \text{Minimum Spill Container Volume} &= 17,46 \text{ m}^3 \times 110\% = 19,206 \text{ m}^3 \end{aligned}$$

Based on the applicable regulations, the minimum capacity of a spill container must be able to accommodate at least 110% of the total volume of waste stored. The total minimum spill container capacity required to accommodate all liquid waste is 19.206 m³. Therefore, the spill container is designed with dimensions of 8 m x 4 m x 0.65 m.

3.6 Measurement of Lighting Needs

Lighting facilities are one of the essential components that must be provided in a hazardous and toxic waste temporary storage. Adequate lighting is required to support storage, handling, and management activities safely, while also reducing the potential risk of occupational accidents within the storage area.

The lighting standard is determined based on the building function [7]. In this design, the building is classified as a warehouse, with a minimum illumination level of 100 lux, which is adjusted to meet the operational activity requirements within the storage area. The lighting system in the hazardous and toxic waste temporary storage is designed using LED lamps with a power rating of 23 watts and a nominal luminous flux of 3000 lumens.

$$N = \frac{E \times L \times W}{\phi \times LLF \times Cu \times n}$$

$$= \frac{100 \times 9,3 \times 9,1}{3000 \times 0,7 \times 0,5 \times 1}$$

$$N = 8,07 \approx 9$$

Based on the calculation results, it was determined that the temporary storage area for hazardous and toxic waste requires 9 lighting points to ensure optimal illumination within the room.

3.7 Measurement of Ventilation Needs

Temporary storage of hazardous waste must have good air circulation to prevent gas accumulation and reactions with the stored hazardous waste [8]. The ventilation should meet the standard with a minimum area of 10% of the building area [9].

$$\text{Minimum Ventilation Area} = \text{Room Floor Area} \times 10\%$$

$$\text{Minimum Ventilation Area} = 84,63 \text{ m}^2 \times 10\%$$

$$\text{Minimum Ventilation Area} = 8,463 \text{ m}^2$$

The total area of the room is 8.463 m². Therefore, the ventilation is designed with dimensions of 1.2 x 1.2 m per unit, consisting of 6 units. These will be installed with 5 units on the right side and 5 unit on the left side. This arrangement is intended to provide adequate air circulation within the room. The ventilation design is determined based on the requirement to ensure sufficient air exchange and maintain indoor air quality in accordance with building ventilation design principles [10].

3.8 Measurement of Forklift Lane

The use of material handling equipment in the form of a forklift for transporting hazardous and toxic waste must comply with occupational health and safety requirements. This includes operating the forklift on a strong, level, and stable surface, as well as ensuring sufficient maneuvering space to prevent accident risks. In addition, the operation of the forklift must ensure that the load remains secure and does not spill during the transportation process [11].

The forklift used is a Toyota Forklift Electric 3 Wheel 8FBE15 with a lifting capacity of 1.5 tons. It has maximum lifting height 3.3 m and turning radius between 1.59 m [12]. This forklift is used to support hazardous and toxic waste handling activities, such as lifting, transporting, arranging and stacking waste packaging safely and efficiently within the storage area.

$$\sqrt{\{\text{Diagonal}\}} = \sqrt{\{\text{forklift length}^2 + \text{forklift width}^2\}}$$

$$= \sqrt{\{1,984^2 + 1,055^2\}}$$

$$= 2,55 \approx 3$$

The required lane width for forklift movement is 3 meters.

3.9 Measurement of Temporary Storage Size

$$1 \text{ Stack Height} = \text{Drum Height} + \text{Pallet Height}$$

$$= 100 \text{ cm} + 15 \text{ cm} = 115 \text{ cm}$$

$$3 \text{ Stack Height} = 115 \text{ cm} \times 3 = 345 \text{ cm} = 3,45 \text{ m} + 1 \text{ Safe Distance} = 4,45 \approx 4,5 \text{ m}$$

Therefore, the final size of temporary storage is 9.3 m x 9.1 m x 4.5 m.

3.10 Measurement of First Aid and Fire Extinguisher Needs

Safety equipment is a mandatory component in the hazardous and toxic waste temporary storage, particularly in industries that generate hazardous waste with flammable and potentially explosive characteristics. The temporary storage facility must be equipped with safety equipment such as a first aid kit and a portable fire extinguisher (APAR) to prevent and control fire risks and other emergency situations. In this design, one first aid kit is provided and placed near the entrance to ensure easy access during emergencies. In addition, one portable fire extinguisher is installed in the same area, near the entrance, to enable a quick and effective response in the event of a fire [13].

3.11 Design of Temporary Storage

This 2D design illustrates the layout of a Hazardous and Toxic Waste Temporary Storage Facility designed to support safe, organized, and regulation-compliant waste management. The main building has approximate dimensions of 9.3 m × 9.1 m and is equipped with a central forklift lane to facilitate loading, unloading, and drum handling operations.

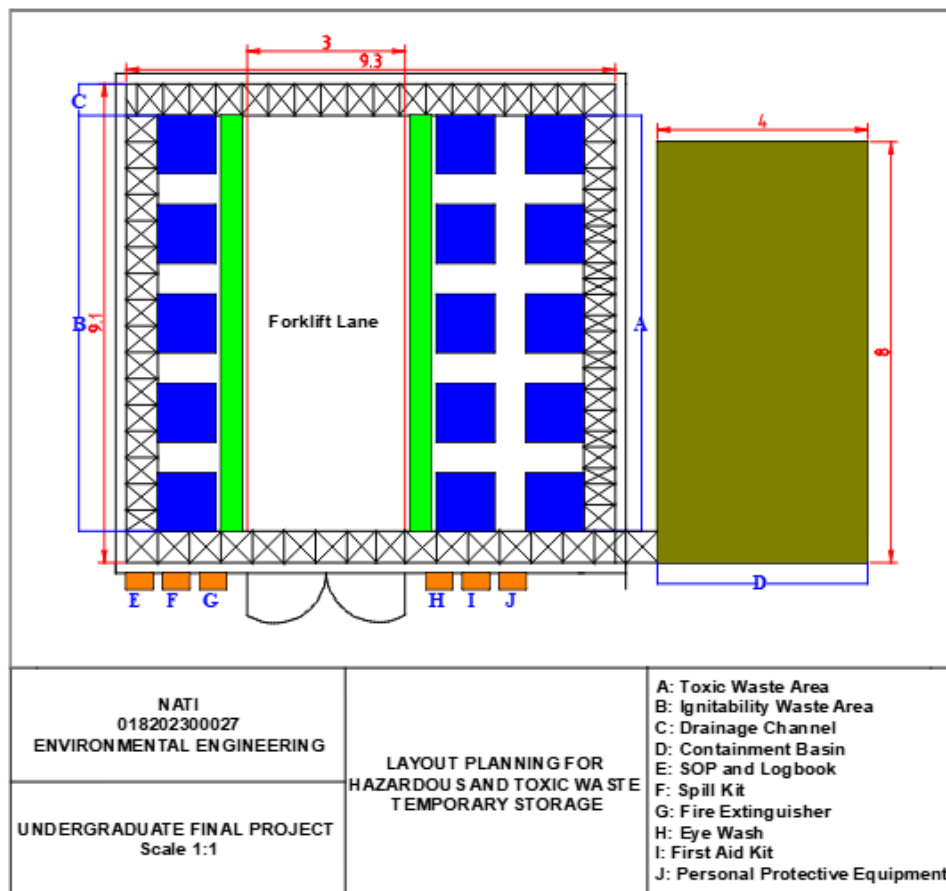


Fig 5. Layout Planning for Hazardous and Toxic Waste Temporary Storage

The storage area is divided into two main zones, which are separated to prevent potential hazardous reactions between different types of waste:

1. Letter A: Waste area with toxic characteristics
2. Letter B: Waste area with ignitability characteristics

4. Conclusion

Temporary storage is a critical stage in hazardous waste management, as it serves as an intermediate facility before the waste is transported for further treatment or final disposal. Improper design and management of hazardous and toxic waste temporary storage can result in environmental pollution, occupational accidents, and regulatory non-compliance. Therefore, hazardous and toxic waste temporary storage must be designed in accordance with technical and safety requirements to ensure effective

containment of hazardous waste and to protect workers and the surrounding environment.

According to the research findings, the hazardous and toxic waste temporary storage facility at PT XYZ is designed with dimensions of 9.3 m in length, 9.1 m in width, and 4.5 m in height. The design has been adjusted to meet technical and regulatory requirements, accommodating 97 drums supported by 13 pallets. The spill containment system requirement has also been fulfilled with a total capacity of 19.206 m³. In addition, the facility is equipped with 6 ventilation units with dimensions of 1.2 m × 1.2 m each, and 9 LED lighting units to ensure adequate illumination. A forklift lane with a width of 3 meters is also provided to support safe and efficient waste handling activities. Overall, the proposed design complies with applicable standards and enhances both operational safety and environmental protection.

5. Recommendation

The recommendations for future studies are to conduct a more detailed analysis of hazardous waste generation rates and variations over time to optimize storage capacity planning. In addition, further evaluation of ventilation performance, including airflow rate calculations and air exchange effectiveness, is recommended to ensure optimal indoor air quality. Future research may also consider integrating risk assessment and cost analysis to evaluate the feasibility and sustainability of the proposed hazardous and toxic waste temporary storage design.

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