



Hazardous Waste Management Planning at Supadio International Airport, Pontianak, Indonesia

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Abstract

Background: Airport operations involve various activities that can generate hazardous and toxic waste, including aircraft and vehicle maintenance, equipment operation, terminal activities, and infrastructure maintenance. Inadequate management of hazardous waste may pose risks to human health, environmental quality, fire, and other safety hazards. Therefore, appropriate hazardous waste management facilities are required to support environmentally responsible airport operations.

Aims: This study aimed to identify the types and sources of hazardous and toxic waste generated at Supadio International Airport, Pontianak, analyze waste generation trends and projections, and develop a temporary storage facility for hazardous and toxic waste in accordance with applicable technical requirements.

Methods: Hazardous waste data were collected through direct observation, interviews, and identification forms covering waste sources, types, generation, and waste characteristics. Waste generation data from 2011–2017 were analyzed to identify generation trends. Waste generation projection was performed using the moving average forecasting method. The planning of the temporary hazardous waste storage facility considered waste characteristics and compatibility, storage arrangement, building dimensions, lighting, natural ventilation, lightning protection, labeling and symbols, and emergency response equipment.

Result & Conclusion: The identification showed that hazardous waste was generated from both airside and landside activities at Supadio International Airport. The identified waste included used batteries, used oil, Sani-Pack waste, used light bulbs, used paint containers, used solvent containers, used pesticide containers, used coolant containers, cartridges, and electronic waste. Several waste streams showed increasing or fluctuating generation trends, particularly Sani-Pack, used light bulbs, and used paint containers. The proposed temporary hazardous waste storage facility has dimensions of 7.2 m × 4.5 m × 3 m and incorporates storage arrangements based on waste characteristics and compatibility. The planning also includes adequate lighting, natural ventilation, lightning protection assessment, emergency response equipment, waste labeling and symbols, and operational recordkeeping. The proposed facility is expected to support safer and more systematic hazardous waste management at Supadio International Airport.

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1. Introduction

The development of the aviation sector has increased airport activities and infrastructure, consequently contributing to the generation of various types of waste (Baxter *et al.*, 2018; Li *et al.*, 2018; Sebastian & Louis, 2021). Among these, hazardous and toxic waste (LB3) requires particular attention due to its potential risks to human health and the environment (Baxter *et al.*, 2018; Rahmawati *et al.*, 2025). Airport activities such as aircraft and vehicle maintenance, ground support equipment (GSE) operation, aircraft cleaning, fueling, and infrastructure maintenance can generate hazardous waste, including used oil, batteries, lamps, paint and solvent containers, pesticides, coolants, and other contaminated materials (Koç & Durmaz, 2015; Mehta, 2015). The diverse characteristics and sources of these wastes require appropriate identification, handling, and storage (Rizaldy *et al.*, 2018; Setiani *et al.*, 2025).

Supadio International Airport in Pontianak, managed by PT Angkasa Pura II, has undergone development to improve its operational capacity and service standards. The airport consists of various airside and landside activities that contribute to hazardous waste generation. Airside sources include the runway, taxiway, apron, GSE, and perimeter areas, while landside sources include the terminal, offices, cargo facilities, and parking areas (Mehta, 2015). The identification conducted at Supadio Airport found several hazardous waste streams, including used batteries, used oil, Sani-Pack waste, used light bulbs, paint and solvent containers, pesticide containers, used coolant, cartridges, and electronic waste.

The management of these waste streams requires consideration of their generation rates, characteristics, and storage compatibility (Rahmawati *et al.*, 2025). Historical waste generation data are important for evaluating generation trends and estimating future storage requirements (Singh & Uppaluri, 2023; Srivastava, & Jha, 2023). In this study, hazardous waste generation data from 2011–2017 were analyzed, and selected waste streams were projected for 2018 using the moving average method (Singh & Uppaluri, 2023; Ghazali *et al.*, 2026). The results were subsequently used as a basis for planning a temporary hazardous waste storage facility, including its capacity, waste arrangement, and supporting infrastructure (Septiani & Wikaningrum, 2023; Setiani *et al.*, 2025).

Therefore, this study aimed to identify the sources and types of hazardous and toxic waste generated at Supadio International Airport, evaluate their generation trends and projected quantities, and develop a temporary hazardous waste storage facility based on waste characteristics and applicable technical requirements. The proposed planning includes storage arrangement, facility layout, lighting, ventilation, lightning protection, labeling and symbols, and emergency response equipment to support safer and more systematic hazardous waste management at the airport.

2. Material and Method

2.1 Research Location

The research was conducted within the operational area of Supadio Airport, Pontianak, located in Kubu Raya Regency, West Kalimantan, Indonesia. The study area covered both landside and airside areas. The landside area included the terminal building, office buildings, cargo facilities, and parking area, while the airside area included the runway, taxiway, apron, ground support equipment (GSE) facilities, and perimeter area.

2.2 Research Method

The research consisted of three main stages: (1) primary and secondary data collection through observation and interviews; (2) analysis of the collected primary and secondary data; and (3) planning of a temporary hazardous and toxic waste (LB3) storage facility.

2.2.1 Data Collection

Primary data were collected using a hazardous and toxic waste identification form referring to Government Regulation No. 101 of 2014. The identification form included information on the source, type, generation, and justification of the hazardous waste. Primary and secondary data were collected through observation and interviews.

2.2.2 Data Analysis

The collected primary and secondary data were analyzed to determine hazardous waste generation and provide a basis for the subsequent storage facility planning (Azizi & Siregar, 2023; Prasetya *et al.*, 2023; Septiani & Wikaningrum, 2023). Waste generation projection was conducted for waste streams that showed an increasing trend from year to year (Ceylan *et al.*, 2020; Singh & Uppaluri, 2023; Srivastava, & Jha, 2023). The projection was performed using the moving average forecasting method. Moving average is a forecasting technique based on the average of values from previous periods (Singh & Uppaluri, 2023; Ghazali *et al.*, 2026). The simple moving average is mathematically expressed (Equation 1) as follows:

$$F_t = \frac{A_{t-1} + A_{t-2} + \dots + A_{t-n}}{n} \quad (1)$$

where F_t is the forecast value for period t , $A_{t-1}, A_{t-2}, \dots, A_{t-n}$ are the actual waste generation values in the previous periods, and n is the number of periods used in the moving average calculation.

2.2.3 Temporary Hazardous Waste Storage Facility Planning

The final stage involved planning the temporary hazardous and toxic waste storage facility based on the results of data collection and analysis. The planning considered the identified hazardous waste types, their generation, waste characteristics, compatibility between waste streams, and applicable requirements for temporary hazardous waste storage (Septiani & Wikaningrum, 2023; Rahmawati *et al.*, 2025; Setiani *et al.*, 2025).

The planning process included site selection, storage layout, lighting, natural ventilation, lightning protection, emergency response equipment, waste labeling and hazard symbols, operator requirements, and supporting infrastructure.

Site selection was evaluated based on the suitability of the proposed location for hazardous waste storage, including flood risk, drainage conditions, distance from public facilities, surrounding land use, and accessibility to waste-generating areas (Li *et al.*, 2026; Uzun *et al.*, 2026).

Waste storage layout was designed by considering the characteristics and compatibility of the identified hazardous waste streams. Waste with different characteristics was assigned to designated storage areas to minimize the risk of incompatible waste mixing and facilitate handling and inspection (Adelino *et al.*, 2021; Azizi & Siregar, 2023; Rahmawati *et al.*, 2025).

Lighting requirements were determined based on the required illumination level for the storage facility. The number of lighting fixtures was calculated using equation 2 as follows:

$$N = \frac{E \times A}{n \times F \times UF \times MF} \quad (2)$$

where N is the required number of lighting fixtures, E is the required illumination level, A is the floor area, n is the number of lamps per fixture, F is the luminous flux per lamp, UF is the utilization factor, and MF is the maintenance factor (Dupl  kov   & Sloboda, 2024; Barjoe & Rodionov, 2024; Setiani *et al.*, 2025).

The floor area served by one lighting fixture was also determined to assess the coverage of the proposed lighting system within the storage facility. This calculation was used to evaluate whether the selected number of fixtures could provide sufficient illumination coverage across the available floor area. The service area of one fixture was calculated using Equation (3) as follows:

$$A_f = \frac{n \times F \times UF \times MF}{E} \quad (3)$$

where A_f is the floor area served by one fixture, while n , F , UF , MF , and E have the same definitions as those given for Equation (2). The resulting service area was then used as a basis for determining the distribution and placement of lighting fixtures within the proposed storage facility (Barjoe & Rodionov, 2024; Setiani *et al.*, 2025).

Emergency Response Equipment

Emergency response equipment was identified based on the potential hazards associated with temporary hazardous waste storage, particularly spills, leaks, and fire. Spill-response equipment included personal protective equipment, empty drums, drum labels, absorbent materials such as sand, granulated clay, and sawdust, detergent powder, brooms, shovels, and metal funnels. Fire protection provisions included portable fire extinguishers and fire detectors (Habibah & Cahyaningrum, 2022; Rahmawati *et al.*, 2025). The spacing of fire detectors was determined based on the planned ceiling height and the applicable installation factor (Azizi & Siregar, 2023).

Waste Labeling and Hazard Symbols

Waste labeling and hazard symbols were determined according to the identified waste characteristics and the requirements of Government Regulation No. 101 of 2014. Labels were planned for individual waste containers and empty containers used for hazardous waste storage. Hazard symbols were assigned according to the characteristics of the waste stored in each designated area, including explosive, flammable, and toxic waste (Azizi & Siregar, 2023; Rahmawati *et al.*, 2025; Setiani *et al.*, 2025).

Operator Requirements

The storage facility planning also considered the need for an operator responsible for hazardous waste storage activities. The operator requirements included the ability to respond to spills and leaks, prevent the spread of hazardous waste, maintain waste records through logbooks and waste balances, and arrange waste according to its type and characteristics in the designated storage areas (Habibah & Cahyaningrum, 2022; Rahmawati *et al.*, 2025).

Supporting Infrastructure

The supporting infrastructure required for the proposed storage facility was determined based on the planned storage arrangement, waste characteristics, emergency response requirements, and operational needs. The required infrastructure included the storage building, fire extinguishers, fire detectors, personal protective equipment, absorbent materials, first-aid equipment, logbooks, lighting fixtures, drums, mesh pallets, and a horizontal storage tank (Septiani & Wikaningrum, 2023; Rahmawati *et al.*, 2025; Setiani *et al.*, 2025). The required capacity and quantity of each infrastructure component were determined according to the proposed storage design and operational requirements.

3. Results and Discussion

3.1 Existing Conditions and Hazardous Waste Identification

Hazardous and toxic waste (LB3) at Supadio International Airport is generated from various operational and infrastructure maintenance activities and is identified in both airside and landside areas. The identified locations in the airside area include the runway, taxiway, apron, ground support equipment (GSE), and perimeter area, while those in the landside area include the parking area, terminal building, office buildings, and cargo building. This distribution is consistent with previous studies showing that airport waste is generated from diverse activities across both airside and landside areas, including aircraft and GSE maintenance, cargo operations, offices, and other airport facilities (Baxter *et al.*, 2018).

The types of hazardous and toxic waste identified at these locations include used light bulbs, Sani-Pack, used batteries, used oil, used coolant, pesticides, water- and oil-based paint, solvents, electronic waste, and cartridges, as presented in Table 1.

Table 1. Identification of Hazardous and Toxic Waste Based on Area and Location at Supadio Airport

Area	Location	Type of Hazardous and Toxic Waste
Airside	Runway	Used light bulbs
	Taxiway	Used light bulbs
	Apron	Used light bulbs

Landside	Ground Support Equipment (GSE)	Sani-Pack, used batteries, used oil, used coolant
	Perimeter area	Used light bulbs, pesticides
	Parking area	Used light bulbs
	Terminal building	Used light bulbs
	Office buildings	Water-based paint containers, oil-based paint containers, solvent containers, electronic waste, used light bulbs, cartridges
	Cargo building	Water-based paint containers, oil-based paint containers, solvent containers, used batteries, used oil, used coolant, used light bulbs

The identification results showed that the hazardous waste generated at the airport consisted of several waste streams with different generation characteristics. These included used batteries, used oil, Sani-Pack waste, used light bulbs, used water-based paint containers, used oil-based paint containers, used solvent containers, used pesticide containers, used coolant containers, cartridges, and electronic waste. The variation in waste types reflects the diversity of activities conducted within airport facilities. Previous research has similarly emphasized that airport waste management systems need to account for diverse waste sources, types, and volumes and should incorporate appropriate facilities and infrastructure for their collection and storage (Baxter *et al.*, 2018). The generation data and waste codes identified in the study are summarized in Table 2.

Table 2. Hazardous and Toxic Waste Generation at Supadio Airport

No.	Type of Hazardous and Toxic Waste	Unit	Generation							Waste Code
			2011	2012	2013	2014	2015	2016	2017	
1	Used batteries	units	–	–	–	10	10	10	10	A102d
2	Used oil	L	–	–	–	2,400	2,400	2,400	2,400	B105d
3	Sani-Pack	L	362.62	380.29	195.25	590.46	950.94	578.27	706.55	A108d
4	Used light bulbs	units	–	–	25	35	40	40	45	B107d
5	Used water-based paint containers	cans	–	–	–	24	28	28	28	B104d
6	Used oil-based paint containers	cans	–	–	–	25	25	25	25	B104d
7	Used solvent containers	cans	–	–	–	75	75	75	75	B104d
8	Used pesticide containers	jerrycans	–	–	–	40	40	40	40	B104d
9	Used coolant containers	jerrycans	–	–	–	6	6	6	6	B104d
10	Cartridges	units	–	–	–	24	24	24	24	B104d
11	Electronic waste	units	–	–	–	–	–	–	–	B107d

The generation data indicate substantial differences among waste types. Used oil, for example, was recorded at 2,400 L annually during 2014–2017, whereas Sani-Pack showed considerably higher and fluctuating quantities during the observation period. Other waste streams, including used light bulbs, used water-based paint containers, used oil-based paint containers, used solvent containers, used pesticide containers, used coolant containers, and cartridges, generally showed

relatively consistent generation quantities during the available observation period, although some waste types exhibited gradual changes over time .

3.2. Hazardous Waste Generation Trend and Projection

Based on the analysis of hazardous and toxic waste generation data, several waste streams showed an increasing trend during the observation period. These waste streams were further analyzed to estimate their generation in 2018. The results of the generation trend analysis and the 2018 projection are presented in Table 3.

Table 3. Hazardous and Toxic Waste Generation Trends and 2018 Projections at Supadio Airport

Type of Hazardous and Toxic Waste	Generation				Projection (2018)	Unit	Description
	2014	2015	2016	2017			
Sani-Pack	590.46	950.94	578.72	706.55	745.24	L	Fluctuating, with an increasing tendency
Used light bulbs	25	25	35	40	45	units	Increasing
Used water-based paint containers	24	24	28	28	28	units	Increased by 14% every two years

The selected waste streams exhibited different generation patterns during the observation period. Sani-Pack showed a fluctuating pattern, increasing substantially from 590.46 in 2014 to 950.94 in 2015, followed by a decrease to 578.72 in 2016 and an increase again to 706.55 in 2017. Based on the moving average projection, the estimated Sani-Pack generation in 2018 was 745.24 L. Moving average has been applied as a forecasting approach for waste generation based on historical generation data ([Singh & Uppaluri, 2023](#); [Ghazali et al., 2026](#)).

In contrast, used light bulbs showed a clearer increasing trend, with generation increasing from 25 units in 2014 to 45 units in 2017. This pattern indicates a gradual increase in the generation of used light bulbs during the observation period.

The generation of used water-based paint containers increased from 24 units in 2014–2015 to 28 units in 2016 and remained at 28 units in 2017. The draft describes this pattern as an increase of approximately 14% every two years. The projected values for the selected waste streams were subsequently considered in determining the requirements for temporary hazardous and toxic waste storage.

The generation trends of the selected waste streams are further illustrated in Figure 1. The figure provides a visual comparison of the changes in waste generation during the observation period and complements the numerical data presented in Table 3.

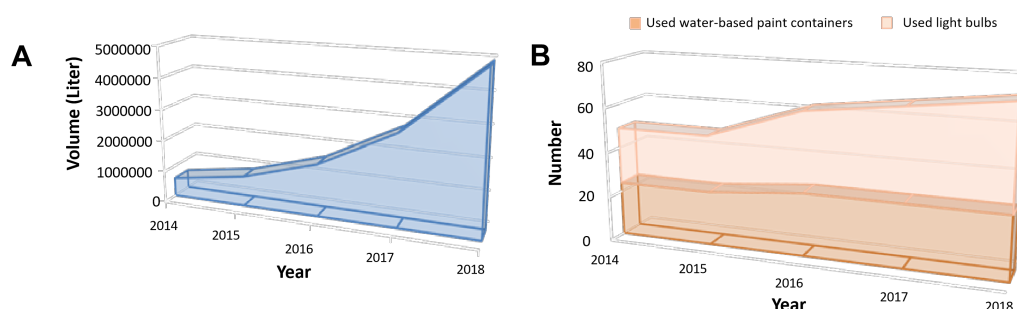


Figure 1. Generation trends of selected hazardous and toxic waste at Supadio Airport: (a) Sani-Pack; (b) used light bulbs and used water-based paint containers.

As shown in Figure 1, the selected waste streams exhibited different generation trends throughout the observation period. Sani-Pack showed an increasing trend in generation over the

observation period. Similarly, used light bulbs exhibited a clear upward trend, indicating a gradual increase in generation over time. Meanwhile, used water-based paint containers showed a relatively moderate increase during the observation period, followed by a stable trend toward the final observation year. These differences indicate that hazardous waste generation at the airport varied among waste streams and did not follow a uniform pattern. Therefore, the historical generation trends of individual waste streams should be considered when estimating future waste quantities and determining the capacity requirements of the temporary hazardous and toxic waste storage facility.

Previous studies have also demonstrated the use of historical waste-generation patterns to estimate future waste quantities for waste-management planning. [Ceylan *et al.* \(2020\)](#) reported that the ARIMA (0,1,2) model provided the best prediction performance among the evaluated models and estimated an increase in annual medical waste generation in Istanbul from approximately 26,400 tons in 2017 to 35,600 tons in 2023. Similarly, [Ghazali *et al.* \(2026\)](#) found that the Holt-Winters Additive method was the most suitable among the evaluated forecasting approaches, with a MAPE of 2.79%, and projected total municipal solid waste generation of approximately 281,710 tons in 2026. These findings support the consideration of historical generation patterns when estimating future waste quantities. In the present study, the different generation patterns observed among the selected hazardous waste streams were therefore considered in projecting their generation for 2018 and subsequently determining the storage requirements of the temporary hazardous and toxic waste storage facility.

4.1. Hazardous and Toxic Waste Management Recommendations

Based on the identified waste generation and characteristics, hazardous and toxic waste generated from airport operational activities and infrastructure maintenance requires management according to the characteristics of each waste stream ([Bian *et al.*, 2025](#)). The proposed management scheme considers the source of waste, its packaging requirements, temporary storage, and subsequent transfer to licensed hazardous waste collectors or treatment facilities ([Baxter *et al.*, 2018](#); [Neksumi *et al.*, 2021](#); [Afifahzari *et al.*, 2024](#)). The recommended management flow for hazardous and toxic waste at Supadio Airport is presented in Figure 2.

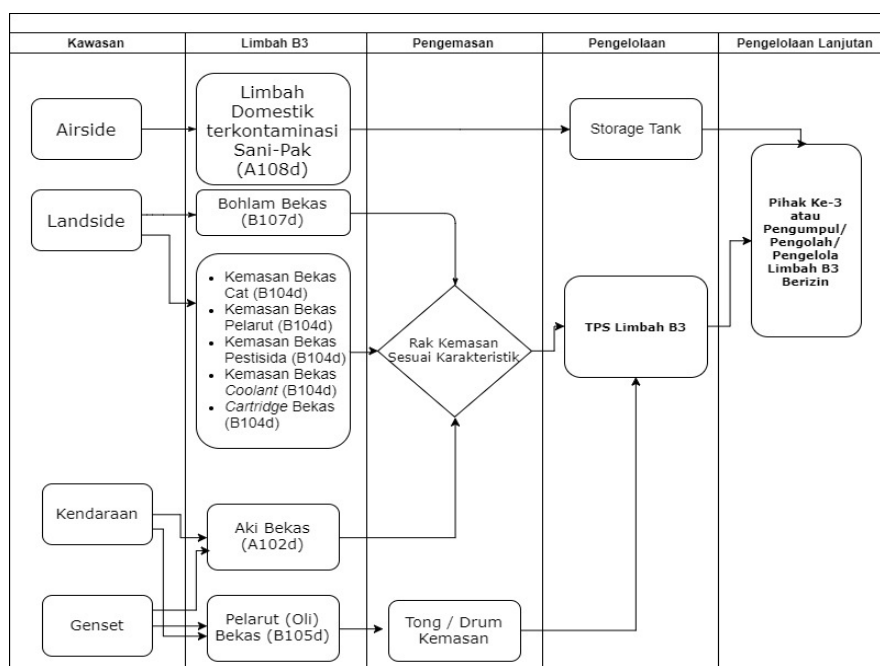


Figure 2. Recommended hazardous and toxic waste management scheme at Supadio Airport.

As shown in Figure 2, hazardous and toxic waste is generated from both airside and landside activities, as well as from supporting activities involving vehicles and generators ([Rizaldy *et al.*, 2018](#)). Waste generated from the airside area includes contaminated domestic waste associated

with Sani-Pack (A108d), which is directed to a storage tank as part of the proposed management system. Meanwhile, waste from the landside area includes used light bulbs (B107d), used paint containers, used solvent containers, used pesticide containers, used coolant containers, and used cartridges (B104d). These waste streams are directed to a packaging rack according to their characteristics before being transferred to the hazardous waste temporary storage facility (TPS Limbah B3) (Anggreini & Amalia, 2026; Prastyo & Dienullah, 2026; Salsabila & Fadhil, 2026).

Waste generated from vehicles and generators includes used batteries (A102d) and used oil (B105d). Used batteries are directed to the characteristic-based packaging rack, whereas used oil is placed in appropriate containers such as drums or tanks before being transferred to the temporary hazardous waste storage facility. This segregation and packaging approach is intended to prevent mixing of waste streams with different characteristics and to facilitate safer handling during temporary storage (Ishchenko *et al.*, 2018; Neksumi *et al.*, 2021).

After collection and packaging, the hazardous waste is directed to the designated temporary storage facility. From the TPS Limbah B3, the waste is subsequently transferred to a licensed third party or an authorized hazardous waste collector, processor, or treatment facility for further management. Thus, the proposed scheme establishes a sequential management flow from the point of generation to final handling, while considering the characteristics and packaging requirements of each hazardous waste stream.

4.1. Planning of the Hazardous and Toxic Waste Temporary Storage Facility

Based on the proposed hazardous and toxic waste management scheme, a temporary storage facility (TPS Limbah B3) is required to accommodate hazardous waste generated from airport operational and infrastructure maintenance activities (Afifazhari *et al.*, 2024; Khumaidah *et al.*, 2025; Prastyo & Dienullah, 2026). Following the identification of waste sources and characteristics, the next stage of the planning process involves establishing a temporary storage facility that complies with the applicable requirements. The planned facility includes provisions for waste storage, daily *logbook* recording, and monthly waste balance reporting (Yudhistira & Jawwad, 2025; Salsabila & Fadhil, 2026). The maximum storage period is 365 days from the date of waste generation, while the proposed storage facility is in the form of a dedicated building.

4.1.1. Site Selection and Waste Storage Layout

The proposed TPS location was selected based on its suitability for hazardous waste storage. The site is not prone to flooding and is supported by a drainage system surrounding the designated area. The minimum distance between the proposed facility and public facilities, represented by the terminal building, is approximately 50 m.

The proposed location is situated at 0°8'37.1076" S and 109°24'12.6324" E. The site is bounded by the office building to the north, vacant land to the east, the PKP-PK building to the south, and the ground handling building to the west. The location is considered strategically positioned within the airport area because it is relatively close to the main sources of hazardous and toxic waste generation.

Considering the different characteristics of the identified waste streams, storage arrangements should be organized according to waste compatibility to prevent mixing between incompatible waste types and minimize potential risks during storage (Firmansyah & Farahdiba, 2025; Sun *et al.*, 2025). The proposed arrangement of hazardous waste within the temporary storage facility is illustrated in Figure 3.

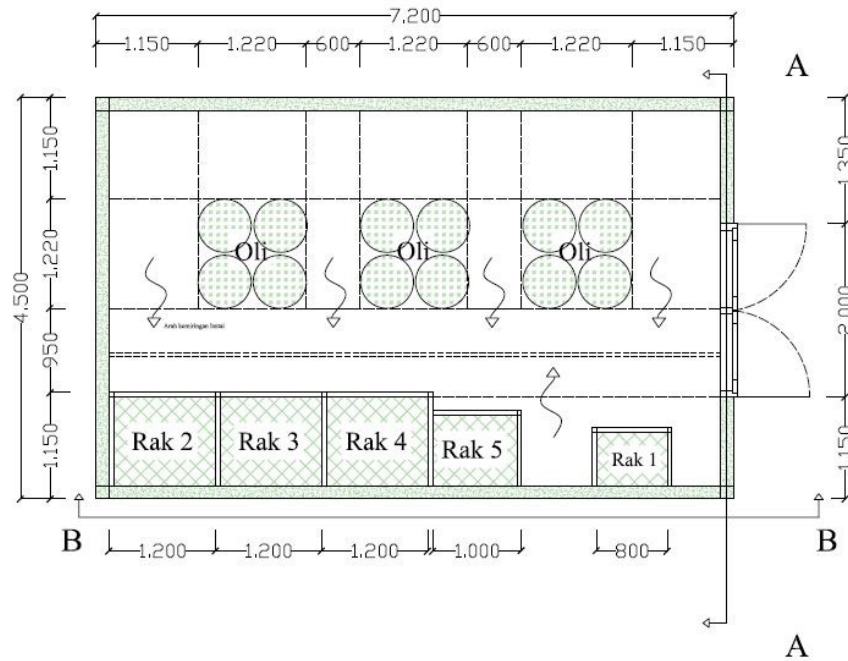


Figure 3. Layout of the hazardous and toxic waste temporary storage facility.

4.1.2. Lighting System

Adequate lighting is required in the temporary hazardous and toxic waste storage facility to support waste handling, storage operations, and routine inspection activities ([Firmansyah & Farahdiba, 2025](#); [Rahmawati et al., 2025](#); [Setiani et al., 2025](#)). Based on the lighting calculation described in the Materials and Methods, the required number of lighting fixtures was calculated as 2.66 fixtures. Since a fraction of a fixture cannot be installed, the value was rounded up to three lighting fixtures to provide adequate illumination throughout the storage area.

The calculated floor area served by one fixture was 12.15 m². Based on this service area and the total floor area of the proposed facility, three lighting fixtures were distributed within the storage area to provide sufficient illumination coverage. The proposed arrangement also facilitates visibility during routine inspection and handling of hazardous and toxic waste. The proposed locations of the lighting fixtures are presented in Figure 4.

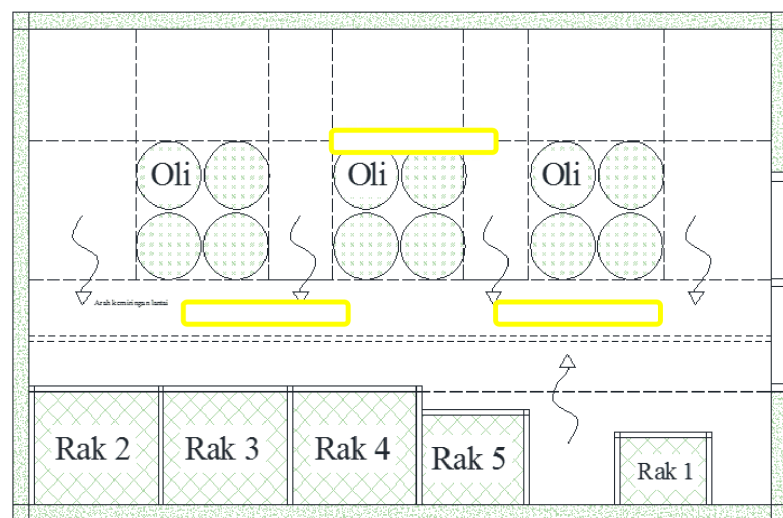


Figure 4. Proposed lighting fixture locations in the hazardous and toxic waste temporary storage facility.

This lighting arrangement provides the basic illumination required for safe operation and routine monitoring of the storage facility, particularly during waste placement, inspection, and handling activities.

4.1.3. Natural Ventilation

Adequate natural ventilation is an important consideration in the design of the temporary hazardous and toxic waste storage facility to support air circulation and reduce the potential accumulation of hazardous vapors ([Rahmawati et al., 2025](#); [Setiani et al., 2025](#); [Sun et al., 2025](#)). The proposed storage facility was designed without a ceiling and incorporated wire-mesh walls to facilitate natural air exchange while preventing the entry of birds and small animals. Based on the ventilation assessment described in the Materials and Methods, the planned opening area exceeded the minimum requirement of 5% of the floor area. Therefore, the proposed design provides sufficient natural ventilation for the storage area while maintaining the physical protection required for stored hazardous waste.

4.1.4. Lightning Protection

The lightning protection assessment was conducted considering the dimensions and position of the proposed storage facility, its building classification, and the surrounding buildings. The proposed facility has dimensions of 7.2 m × 4.5 m × 3.0 m and is located adjacent to taller buildings equipped with lightning protection systems, namely the GSE and office buildings. The lightning risk assessment resulted in a total risk index of 7, based on the combined indices for building use, construction, height, situation, and lightning influence.

Based on the applicable risk classification, the estimated lightning hazard for the proposed storage facility was categorized as negligible. Therefore, the assessment indicated that additional lightning protection was not required for the proposed facility. The location adjacent to existing protected buildings also provides additional consideration in evaluating the lightning exposure of the proposed storage facility ([Rahmawati et al., 2025](#)).

4.1.5. Emergency Response and Fire Protection

Emergency response equipment was incorporated into the proposed storage facility to address potential incidents, particularly hazardous waste spills and fire ([Ding et al., 2020](#); [Rahmawati et al., 2025](#); [Sun et al., 2025](#)). For spill response, the proposed facility was equipped with personal protective equipment, empty drums, drum labels, absorbent materials, detergent powder, brooms, shovels, and metal funnels. These provisions are intended to support the immediate containment and handling of spilled or leaked hazardous waste and to reduce the potential for contamination within and outside the storage area ([Rahmawati et al., 2025](#)).

Fire protection was provided through the installation of a portable fire extinguisher (APAR) and a fire detection system ([Pratama & Kencanawati, 2017](#); [Sun et al., 2025](#)). The proposed fire detector provides an early warning mechanism, which is particularly relevant for a storage facility that may not be continuously occupied outside working hours. Based on the detector spacing calculation described in the Materials and Methods, the spacing between detectors was determined to be 3 m. The inclusion of both fire detection and fire suppression equipment provides an initial response capability for potential fire incidents within the storage facility ([Ding et al., 2020](#); [Mikalsen et al., 2021](#)).

4.1.6. Waste Labels and Hazard Symbols

Proper labeling is required to facilitate the identification and handling of hazardous waste during storage ([Akhdiyat et al., 2025](#); [Pereira et al., 2025](#)). Two types of labels are proposed for the storage facility: a label attached to each hazardous waste container and a label used to identify empty containers intended for hazardous waste storage. Both labels are presented in Figure 5.

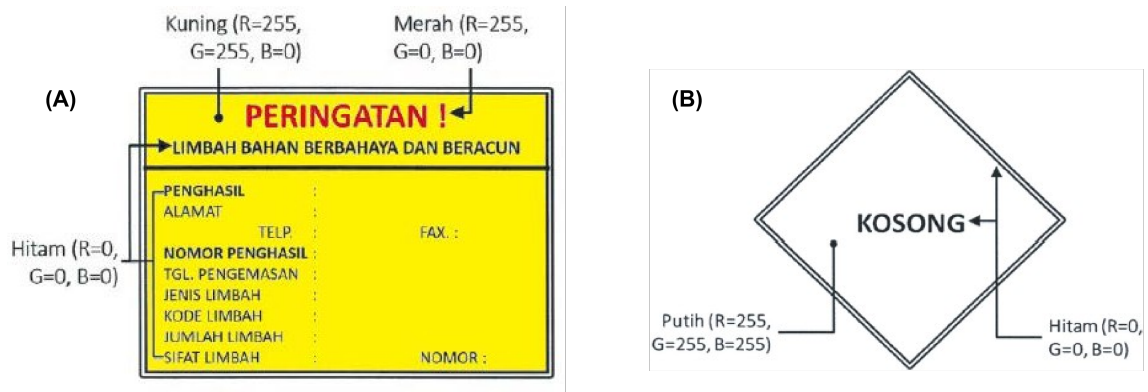


Figure 5. Hazardous and toxic waste labeling: (a) hazardous waste container label; and (b) empty container label.

In addition to container labels, hazard symbols are required to indicate the characteristics of the stored waste. Based on the identified waste characteristics, three hazard symbols are applied in the proposed storage arrangement: explosive, flammable, and toxic. The corresponding symbols are presented in Figure 6.

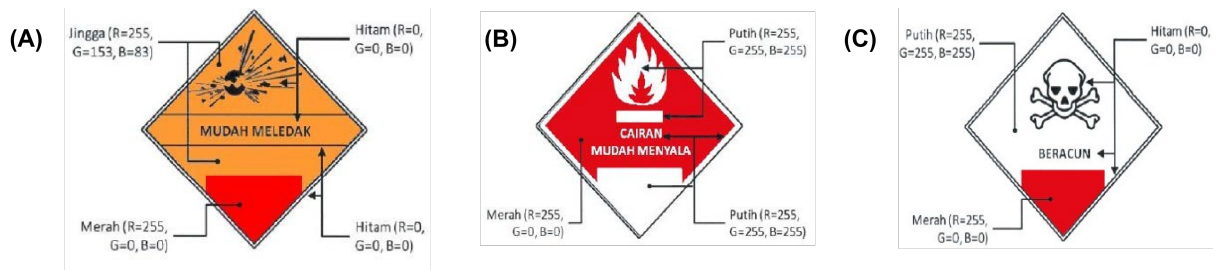


Figure 6. Hazard symbols for hazardous and toxic waste: (a) explosive; (b) flammable; and (c) toxic.

The explosive symbol is assigned to used accumulators, while the flammable symbol is applied to containers used for used oil. The toxic symbol is assigned to the storage areas for used paint containers, pesticide containers, coolant containers, and cartridges. The use of appropriate labels and hazard symbols supports waste segregation and facilitates safe handling and routine inspection within the storage facility ([Hormozoni et al., 2025](#); [Ramezanifar & Ramezanifar, 2026](#)).

4.1.7. Operator Requirements

The temporary hazardous and toxic waste storage facility requires a designated operator responsible for the proper handling and storage of hazardous waste. The operator should be capable of responding to spills and leaks, preventing waste from spreading outside the storage area, maintaining waste records through a *logbook* and waste balance, and arranging waste according to its type and characteristics. ([Prasetya et al., 2023](#); [Rahmawati et al., 2025](#); [Sun et al., 2025](#)).

The overall arrangement of the proposed storage facility, including the designated storage areas and supporting facilities, is illustrated in Figure 10.



Figure 10. Three-dimensional illustration of the proposed temporary hazardous and toxic waste storage facility at Supadio Airport.

Based on the proposed facility design and the identified waste characteristics, the required infrastructure and supporting equipment are summarized in Table 4, including their functions, capacities, and quantities.

Table 4. Infrastructure requirements for hazardous and toxic waste management at Supadio Airport

No.	Infrastructure/Equipment	Function	Capacity	Quantity
	Temporary hazardous and toxic waste storage facility	Storage of hazardous waste generated from various sources	32.4 m ²	1 lot
a.	Fire extinguisher (APAR)	Emergency response in the event of fire	9 kg	1 unit
b.	Fire detector	Detection of fire	—	1 unit
c.	Personal protective equipment (mask and gloves)	Protection of operators against potential accidents	—	1 set
1	d. Absorbent materials (sand, granulated clay, and sawdust)	Absorption of liquid hazardous waste in the event of spills or leaks	1 m ³	1 unit
	e. First-aid kit	First-aid response to workplace accidents	—	1 unit
	f. <i>Logbook</i>	Recording hazardous waste activities in the storage facility	—	1 unit
	g. Fluorescent lamps	Illumination of the storage facility	—	6 units

2	Drum/container	Storage of used lubricating oil	200 L	12 units
3	Mesh pallet	Storage of used hazardous-waste packaging	0.2 m ³	1 unit
4	Mesh pallet	Storage of used hazardous-waste packaging	0.68 m ³	1 unit
5	Mesh pallet	Storage of used hazardous-waste packaging	1.08 m ³	3 units
6	Horizontal storage tank	Storage of domestic waste contaminated with Sani-Pack	200 m ³	2 units

4. Conclusion

This study identified hazardous and toxic waste generated from both airside and landside activities at Supadio Airport, with different generation patterns among waste streams. The findings were used as a basis for planning a 32.4 m² temporary hazardous and toxic waste storage facility, including appropriate waste segregation, labeling, hazard symbols, lighting, ventilation, and emergency equipment. The proposed facility provides an integrated approach for the safe storage and management of hazardous and toxic waste generated from airport operational and maintenance activities.

5. References

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