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Challenges in Hazardous Waste Management: A Case Study of Talang Gulo Landfill in Jambi City

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A B S T R A C T

The improper storage of Hazardous and Toxic Waste (HTW) at the Talang Gulo Landfill prompted a study to analyze the implementation of Hazardous and Toxic Waste Management (HTWM). The study used a qualitative case study approach involving interviews, observations, and document analysis. 10 informants were selected through purposive sampling. The findings revealed several issues including a lack of trained personnel, limited budget, inadequate Standard Operating Procedures (SOPs), insufficient storage facilities, non-compliance with Personal Protective Equipment (PPE) use, and poor supervision. These findings highlight the need for the development of SOPs, worker training, facility upgrades, and improved supervision to enhance HTWM at the Talang Gulo Landfill.

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INTRODUCTION

The increase in population and rapid development across various sectors, such as industry, infrastructure, and public services, have contributed to improving societal welfare. However, activities in these sectors also generate waste, including Hazardous and Toxic Waste (HTW), which requires special handling (Sidik & Damanhuri, n.d.). HTW, produced alongside various useful processes like industrial operations or natural processes, can have harmful effects on living organisms (Qian et al., 2022). HTW consists of substances or other components that can pollute, damage, or endanger the environment and human health, either directly or indirectly (Indonesia, 2021). HTW is classified based on hazardous characteristics such as toxicity, flammability, corrosivity, and carcinogenicity, as outlined in Government Regulation No. 22 of 2021 and Ministry of Environment and Forestry Regulation No. 6 of 2021. Based on these characteristics, HTW requires proper management in accordance with the applicable regulations (Hardiyanto et al., 2022) (Wardhani & Salsabila, 2021).

Several studies highlight the negative impacts of HTW on health and the environment. Hazardous waste not only poses risks to the surrounding air, water, and soil but also degrades soil ecosystems and reduces fertility, which is essential for plant growth and human health in various ways (Exposto & Sujaya, 2021) (Saravanakumar et al., 2022). The health effects of hazardous waste can be both short- and long-term (Yurnalisdel, 2023). Mercury, lead, arsenic, chromium, and cadmium are among the most common heavy metals that cause toxicity in humans, significantly affecting cells and organs. Poisoning may be acute or chronic after exposure through water, air, or food (Kurniawidjaja et al., 2021) (Yurnalisdel, 2023). Mercury can affect the central nervous system, causing neurological disorders such as tremors, cognitive impairment, and kidney damage (Kurniawidjaja et al., 2021). Long-term exposure to arsenic and cadmium can lead to severe organ damage, including skin and lung cancer from arsenic exposure and kidney, bone, and lung damage from cadmium (Abd Elnabi et al., 2023).

Akpan and David O. reported in their study that the WHO estimates up to one-third of Africa's disease burden is caused by environmental risk factors and poor HTW management (Akpan & Olukanni, 2020). A serious example occurred in 1976 when methylmercury (MeHg) poisoning from fish in Minamata Bay caused 800 cases of illness and 120 deaths among Minamata residents, following 45 years of mercury waste dumping by Company X (Susdarwono, 2022). Additionally, a study on illegal hazardous waste disposal into the Kim Kim River in Pasir Gudang, Malaysia, found that 975 students experienced respiratory illnesses due to chemical exposure (Ibrahim et al., 2021). Research on the impacts of HTW disposal in Lakardowo Village revealed pollution leading to dermatitis, respiratory issues, and declining well water quality. These findings demonstrate that improper hazardous waste management can have serious consequences for human health and the environment (Wardani et al., 2021).

The Talang Gulo Landfill in Jambi City produces HTW from its daily operational activities. The HTW generated from landfill operations may contain

hazardous pollutants such as heavy metals, toxic chemicals, and harmful organic compounds. If not properly managed, these pollutants can seep into the soil, water, and air. Exposure to these pollutants has been shown to increase the risk of serious health issues. Studies indicate that areas near hazardous waste disposal sites have a higher prevalence of preterm births and low birth weights (Fazzo et al., 2023). The long-term impacts of HTW can cause permanent damage to the health of the communities around the landfill and worsen the surrounding environmental quality. Observations revealed that HTW management at this landfill has not yet fully complied with applicable standards. Inadequate storage facilities and the discovery of certain types of waste, such as used batteries and oil filters, in improper locations indicate the potential for environmental contamination and health hazards. Therefore, this study aims to analyze the management of HTW at the Talang Gulo Landfill and provide recommendations for improvement.

LITERATURE REVIEW

Hazardous Waste Management

Hazardous and Toxic Materials (HTM) are substances that can harm the environment, human health, or other organisms due to their type, concentration, or quantity. Hazardous and Toxic Waste (HTW) is the by-product of human activities containing HTM, which poses potential dangers. The U.S. Environmental Protection Agency defines hazardous waste as waste that poses risks to health and the environment (United States Environmental Protection Agency (EPA), 2021). While the United Nations identifies it as waste with toxic, infectious, radioactive, or flammable characteristics.

HTW requires special management to prevent environmental damage. It may exist in solid, liquid, sludge, or gas forms, primarily produced by chemical and industrial activities. Improper handling of HTW can contaminate water and soil, making it crucial to follow regulations covering collection, storage, utilization, transportation, and disposal. In Indonesia, HTW management is governed by the Ministry of Environment and Forestry Regulation No. 6 of 2021. Effective management reduces waste production and pollution, and entities generating HTW must obtain permits to ensure compliance (Indonesia, 2021).

Human Resources (HR)

HR is a vital element in management, as the quality of HR impacts the success of operations (Khairil et al., 2024). In managing HTW at Talang Gulo Landfill, key roles include waste management supervisors, operators, inspectors, and experts, all responsible for overseeing and ensuring smooth operations in accordance with applicable regulations.

Funding

Funding is a crucial factor in the success of Hazardous and Toxic waste management. Talang Gulo Landfill secures funding from various sources, including government budgets, third parties, and government programs.

Efficient use of funds is essential for the sustainability of Hazardous and Toxic waste management activities (Mujayaroh & Rohmat, 2020).

Facilities and Infrastructure

Facilities and infrastructure include temporary storage facilities, transport equipment, and other infrastructure used to support HTWM (Igustita Wirodimurtia et al., 2022). Adequate infrastructure is essential for the smooth operation of Hazardous and Toxic waste management processes at Talang Gulo Landfill.

Supervision

Supervision is a structured process for comparing results with predetermined standards. Evaluations are conducted at the beginning, middle, and end of the program to identify challenges and measure success (Azwar, 2020).

Figure 1. Mind Map

These elements, human resources, funding, facilities, and supervision, are closely interconnected and play a crucial role in ensuring the effective implementation of Hazardous and Toxic waste management. The integration and efficiency of each component will determine the overall success of HTWM.

METHODOLOGY

This research employs a descriptive qualitative methodology with a case study approach. This research uses a descriptive qualitative methodology with a case study approach at the Talang Gulo Sanitary Landfill from May to July 2024. A purposive sampling technique selected ten informants, including the Head of the Landfill, K3 Coordinator, Laboratory Coordinator, technicians, and other key personnel. Data were collected through observation, in-depth interviews, and document analysis. Primary data came from observations and interviews, while secondary data were gathered from landfill archives. The main data collection instrument was the researcher, supported by interview guidelines, field notes, recording devices, and a camera. Data analysis followed reduction, presentation, and conclusion drawing using content analysis and NVivo software. Data validity was ensured through triangulation of sources and methods (Assyakurrohim et al., 2022).

RESEARCH RESULT

The data on the types, sources, characteristics, and quantities of hazardous and toxic materials waste generated at the Talang Gulo landfill is obtained from

the technical documentation on Hazardous and Toxic Waste (HTW) storage owned by the landfill. According to that document, various types of HTW produced have toxic, corrosive, or flammable characteristics. Examples of HTW generated include used oil, used oil filters, used batteries, electronic waste, used ink cartridges/bottles, used HTW packaging, sludge from wastewater treatment, contaminated HTW waste, reagents HR, and reagents HR+. These wastes originate from various sources such as workshop activities, generators, laboratories, and office administration. The amount of waste generated also varies, and the timing of replacements, such as different oil changes for each heavy equipment, also affects the quantity of used oil waste produced. Below is the HTW data generated by the landfill, presented in Table 1.

Table 1. Name, Source, Characteristics, and the Amount of Hazardous Waste Generated

No.	Waste Name	Waste Code	Source	Characteristics	Waste Quantity	Remarks
1.	Used Oil	B105d	Workshop activities dan genset	Flammable	300-350 liters/month	The oil change interval varies for each heavy equipment (+ every 250 operating hours)
2.	Used Oil Filter	B109d	Workshop activities	Toxic	14 pcs/month	The filter is replaced with each oil change
3.	Used Rags	B110d	Workshop activities	Flammable solid	50kg/ month	-
4.	Used Batteries/ Accumulator	A102d	Workshop activities	Toxic, Corrosive	6 units/ year	Per-event
5.	Electronic Waste (Used lamps, Printed Circuit Boards (PCBs), metal wires)	B107d	All rooms in the workshop and office areas of Talang Gulo Landfill	Toxic	5 units /year	Per-event
6.	Used Ink Cartridges/Bottles	B353-1	Office administration	Toxic	2 units/ month	-
7.	Used HTW Packaging	B104d	Workshop activities	Toxic	25 kg/month	-
8.	WWTP Sludge	A108d	Workshop activities	Toxic	-	Cannot be estimated yet
9.	HT-	A108d	Workshop	Toxic	5 kg/month	-

			activities			
10.	Contaminated Waste Methanol (CH3OH)	A110b	LTP area	Flammable	1000 liter	-
11.	Reagen HR dan HR+	A106d	Laboratory	Toxic, Corrosive, Hazardous to the environment	218ml/ month	-
13.	Eon 500 Acid Cleaner, Eon 399 Acid Cleaner, Eon Alkalie Cleaner	A352-1	LTP area	Corrosive, Mudah terbakar	150 liter/year	-
14.	Eon Antifoam 61.59	A352-1	LTP area	Corrosive, Mudah terbakar	200 liter/year	-
15.	Eon Brocide	A352-1	LTP area	Corrosive, Mudah terbakar	50 liter/year	-

Source: Technical Details Document for Hazardous Waste Storage at Talang Gulo Landfill

Based on interviews and observations conducted at UPTD Talang Gulo Landfill, Jambi City, several key aspects have been identified that influence the effectiveness of HTWM at the site. These include human resources, funding, infrastructure, and supervision.

1. Human Resources:

Human resources (HR) are a vital component of management and play a crucial role in the success of an organization. High-quality and competent HR can provide optimal service to customers and the community. One of the major challenges in managing hazardous waste at Talang Gulo Landfill is the lack of both the quantity and quality of the workforce needed to handle Hazardous and Toxic waste.

"*For administrative tasks, it's sufficient. But we still need personnel specifically for managing the HTW storage area.*" **(T.1, T.3, T.4, T.7, T.8)**

According to interviews with the informants, no specialized training has been provided to workers related to hazardous waste management.

"*So far, there has been no training.*" **(T.4)**

This shortage of human resources is further exacerbated by the fact that some workers are required to take on multiple roles, meaning their responsibilities are not limited to HTWM but also include general operations at the landfill, as stated by informant T.6:

"*For instance, I'm the environmental impact controller, but because we're understaffed, I also oversee the LTP.*" **(T.6)**

Additionally, the task allocation system is ad-hoc, where duties are assigned based on immediate needs without a formal system in place. For example, as stated by informant T.3, mechanical staff are often asked to assist with waste transportation, although their primary duty is equipment repair.

"*Currently, the mechanical crew helps with transporting waste...*" **(T.3)**

2. Financial Conditions:

Limited funding also presents a significant challenge in managing hazardous waste at Talang Gulo landfill, particularly in efforts to improve and develop facilities. Based on interviews with informants T.1 and T.3, it was revealed that Talang Gulo landfill's funding comes from the Regional Public Service Agency (BLUD). Although funds for general waste management are available, the budget specifically allocated for HTWM is often inadequate. This is due to budget priorities being more focused on Talang Gulo landfill's operational management, while funds for HTWM have not been specifically allocated. This is supported by the following statements:

"*There is no specific budget yet... We only have the BLUD budget, it's combined with the operational budget.*" **(T.1, T.3)**

This budget limitation has resulted in a lack of essential facilities and equipment. Furthermore, the limited funds have delayed partnerships with third parties for the transportation and processing of HTW. HTW produced by daily operations at the Talang Gulo landfill, such as used lubricants, has only been stored in the storage area since 2021.

"*We don't have anyone to transport the waste yet, no third party involved.*" **(T.5, T.6, T.7)**

"*I've been working here since the landfill opened, and no one has ever collected our hazardous and toxic waste.*" **(T.7)**

The lack of funding has also delayed the development of Standard Operating Procedures (SOP) specific to HTW management, as well as technical plans. These two documents should serve as primary guidelines for handling hazardous waste, but they have not yet been completed or approved due to the lack of funds to hire the expert consultants needed for the drafting process. Without these SOPs and technical plans, HTW management is carried out without clear standard procedures, often leading to non-compliance with existing regulations and increasing the risk of mishandling the waste.

3. Infrastructure:

The infrastructure for HTWM at the Talang Gulo Landfill landfill is also inadequate. According to the interviews, the current storage facility is a repurposed warehouse that was rarely used before. Based on observations, the HTW storage area does not meet the standards set out in the Ministry of Environment and Forestry Regulation No. 6 of 2021, Article 67. The storage

space lacks proper design and construction. Essential facilities such as fire extinguishers, spill kits, pallets for waste arrangement, and other safety equipment are not yet available. This is reflected in the interview excerpts and observational findings below (Table 2) (Figure 2):

> *"No, not yet. First, there should be a separate sink, and that sink should also have a shower... Then there should be a rack or cabinet for small HTW... Also, HTW should not be placed directly on the floor. Then, labelling, SOPs. There are fire extinguishers, but some are expired, some are already empty. We do have hydrants outside, though."* **(T.3)**

Table 2. Observation Results of HTW Storage Facility at Talang Gulo Landfill Landfill

Facility/Equipment	Availability	Status in the Field	Specified Standards
Emergency Response Equipment			
Firefighting Equipment	Available	Functional hydrant, expired fire extinguishers	Functional firefighting equipment
Fire Detection System	Not available	-	Functional fire detection system
Emergency Response SOP	Available	Not specifically created for HTW	SOP specific to emergency response for HTW
Support Facilities for HTW at Storage Facility			
First Aid Facilities (P3K)	Not available	Not available within the storage facility	Complete first aid facilities
Loading/Unloading Equipment	Available, but incomplete	Forklift available, incomplete safety equipment. Pallet jack, spill kit, drum handler, and containment pallets are not yet available	Complete loading/unloading equipment for handling HTW
Drainage and Spill Containment Basin	Not available	Not available within the Storage facility	Spill containment basin meeting specified dimensions

Source: Field Observation Data (2024)

Figure 2. The condition of the hazardous and toxic waste storage room

Furthermore, it was found that the Personal Protective Equipment (PPE) provided is incomplete or, in other words, insufficient. Interview results also

revealed that compliance with the use of PPE remains low. Various reasons were cited, ranging from discomfort, negligence, a sense of safety without PPE, to issues related to the unsuitability of the equipment.

> *"…The reason is that it feels uncomfortable to me, it disrupts flexibility sometimes, especially the helmet – it really hinders flexibility. The mask even more so. PPE is meant for safety, you know, but yeah, it's still a violation."* **(T.8)**

4. Supervision:

   Supervision of workers at Talang Gulo Landfill is carried out daily by field supervisors. This oversight focuses on ensuring workers comply with general regulations, including the use of PPE, and that they perform their duties appropriately. Supervisors routinely reprimand workers who fail to adhere to PPE rules, and in some cases, violators are given verbal warnings or formal Warning Letters. However, supervisors acknowledged that the existing sanctions, such as SPs, do not effectively deter non-compliance, and many workers continue to neglect the use of PPE.

   > *"We always remind them, when we are there, they put on their masks and follow the SOP. But as soon as we move away, they take them off."* **(T.9)**

   In addition, supervision of hazardous waste management procedures is almost non-existent. This is due to the lack of approved Standard Operating Procedures (SOP) for HTW management and the technical plan, which has not yet been approved due to insufficient funds to hire the expert consultants needed to complete these documents.

DISCUSSION

The first step in hazardous and toxic waste management (HTWM) is the identification of the waste. This process involves determining the source of Hazardous and Toxic materials, a crucial component of the waste management system. It helps to establish whether the generated waste falls under the category of HTW and how it should be managed (Indonesia, 2021). The characteristics of HTW are detailed in Table 1.

The findings of this research show that the HTWM at Talang Gulo Landfill is not optimal. Various factors affect the operational performance of hazardous waste management. One major issue is the lack of trained human resources. Workers at Talang Gulo Landfill have not received specialized training in HTWM. This lack of knowledge leads to mishandling of hazardous waste, increasing the risk of contamination and health hazards. Therefore, it is crucial for management to support and empower employees to make necessary changes. Management should provide incentive and reward systems, as well as relevant information, to raise environmental awareness among all members of the organization (Molina-Azorin et al., 2021) (Peng et al., 2024). Education and training programs should focus on improving employees' skills in hazardous waste management, enabling them to contribute to the organization's sustainability goals (AlKetbi & Rice, 2024) (Conti et al., 2024). The purpose of this training program is to familiarize employees with environmental

regulations, recordkeeping, waste management, and emergency response procedures relevant to their job roles, ensuring they can perform their duties safely and efficiently. Training for workers is a crucial strategy in enhancing sustainability, particularly in the context of environmental management (Conti et al., 2024).

By equipping employees with the knowledge and skills necessary for handling hazardous waste properly, training programs not only improve operational efficiency but also minimize risks to both human health and the environment. This aligns with broader human resource management strategies that focus on capacity building and continuous improvement. Integrating regular training into workforce development fosters a culture of safety and responsibility, which is essential for long-term sustainability and compliance with regulatory standards. Thus, training is a key component in ensuring the sustainable management of resources and operational practices. Performance evaluation followed by environmental training can improve employee skills, enhance their satisfaction and loyalty, and motivate them to engage in positive environmental practices (Supriyadi & Hadiyanto, 2018). The Occupational Safety and Health (OHS) program is great way to create a protection system for employees through the integration of management elements, labor, conditions, and the work environment, in order to minimize the risk of accidents (Anwar et al., 2023).

In addition to the lack of training, the workload at the Talang Gulo landfill is unevenly distributed. Many workers are required to take on multiple roles, which divides their focus on hazardous waste management. This double workload negatively impacts productivity and increases the risk of workplace accidents (Hermawan, 2022). An imbalanced workload can significantly affect employee job satisfaction (Inegbedion et al., 2020) (Pangabean et al., 2024). In hazardous waste management, there must be clear task specifications for responsibilities such as waste identification, temporary storage management, and coordination with third parties for the transportation and processing of hazardous waste. Clear task distribution helps to reduce confusion and improve efficiency, ensuring that each employee understands their roles and responsibilities. A well-structured organizational hierarchy with clear task assignments is essential for the Talang Gulo landfill. The better the organizational structure, the more it will enhance the organization's performance (Ali et al., 2022).

Financial constraints also pose a significant challenge, affecting various aspects of hazardous waste management at the landfill. Most of the allocated funds are directed toward the landfill's operational management, leaving HTW with insufficient attention. This affects the availability of adequate infrastructure. The hazardous waste storage facility at Talang Gulo landfill does not meet the standards outlined in Article 60, Paragraph 2 of the Ministry of Environment and Forestry Regulation No. 6 of 2021. Additionally, the HTW storage facility lacks the necessary standard equipment, such as fire extinguishers, spill kits, and pallets. Environmental expenditure is a key factor

in developing environmental policies, and it is important to monitor and evaluate its volume and usage (Mihaliková et al., 2022).

Funding limitations have also impacted the landfill's ability to develop Standard Operating Procedures (SOPs) and technical plans for hazardous waste management. An SOP is a document containing written instructions for routine activities that must be carried out effectively and efficiently to prevent variations or deviations that could disrupt performance (Hidayah et al., 2023). Without approved SOPs, workers and supervisors lack clear guidelines to ensure that HTWM complies with the standards set forth in Ministry of Environment and Forestry Regulation No. 6 of 2021. The delay in preparing these documents is due to insufficient funds to hire the necessary expert consultants to complete the SOPs and technical plans. Without clear SOPs, supervision of HTWM becomes limited, and workers often fail to follow appropriate procedures (Taufiq, 2019). Implementing effective SOPs is critical for ensuring the smooth operation of a company or institution, particularly in hazardous waste management (Hidayah et al., 2023).

Interviews conducted during the research revealed that the current personal protective equipment (PPE) is inadequate, and some workers do not comply with its use. Poor work habits and a lack of proper PPE contribute to the adverse health effects experienced by these workers. One reason for non-compliance with PPE usage at the Talang Gulo landfill is discomfort, even though workers understand its importance. This finding aligns with research conducted at the Sisdo landfill in India, where only a few workers wore complete PPE despite being aware of it (Khanal et al., 2021). Workers reported experiencing headaches, injuries, skin problems, and respiratory illnesses due to inadequate PPE. The shortage of PPE is likely due to limited funding for waste management. Waste collectors in developing countries face occupational health problems due to a lack of PPE (Melaku & Tiruneh, 2020).

Another challenge identified is the lack of effective supervision. Field supervisors monitor and reprimand workers who fail to wear PPE, but the sanctions imposed are limited to warnings or written reprimands, which are not strong enough to serve as deterrents. Stricter sanctions are needed to enforce worker compliance with safety regulations (Tyas Damayanti, 2022). Supervision is a key element in ensuring that HTWM is carried out according to procedures and regulations. However, this study's findings indicate that supervision at the Talang Gulo landfill remains focused on physical presence and worker productivity rather than compliance with HTW management procedures. Consequently, workplace safety and hazardous waste management procedures are often neglected. The insufficient number and capacity of supervisory institutions, along with limited oversight of HTW management, present unique challenges for hazardous waste management in Indonesia. Research has shown that in HTWM in industrial areas, government oversight plays a crucial role, although its power is limited. Local supervision is also key in coordinating between stakeholders, with the potential to enhance information exchange and encourage broader engagement. Therefore, strong communication and supervisory mechanisms are necessary to improve the efficiency of hazardous

waste management (Sheng et al., 2020). The lack of supervision is closely linked to the absence of official SOPs governing HTW handling. The delay in SOP approval is due to the need for expert consultants, which has been postponed because of limited funds. As discussed earlier, insufficient funding has a cascading effect on the entire waste management system at the Talang Gulo landfill.

CONCLUSIONS AND RECOMMENDATIONS

The management of hazardous waste at the Talang Gulo landfill is suboptimal due to constraints in human resources, funding, and inadequate facilities. The existing supervision is ineffective, as there are no clearly defined Standard Operating Procedures (SOPs), and the sanctions related to violations of Personal Protective Equipment (PPE) usage have not proven to be deterrent. Each of these factors mutually exacerbates the situation, highlighting the urgent need for the development and approval of SOPs for hazardous waste management, increased funding allocation, and the establishment of facilities that meet established standards.Furthermore, training for personnel involved in hazardous waste management should be provided promptly, while supervision must be strengthened through stricter sanctions and ongoing education regarding the importance of PPE for worker safety. Despite the Talang Gulo landfill's emphasis on managing organic and non-organic waste, the hazardous waste generated from daily operations necessitates special attention to mitigate negative impacts on the environment and public health.

ADVANCED RESEARCH

One of the limitations of this research is the restricted number of informants and the observation coverage, which was confined to a single location. Nevertheless, the findings remain pertinent as they offer a comprehensive overview of the challenges encountered in managing hazardous and toxic waste generated by the landfill. Future researchers may focus their studies on the effectiveness of Standard Operating Procedures (SOPs), training programs, storage facilities, disciplinary measures, and collaborations with third-party entities.

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