

ORIGINAL RESEARCH

Hazardous and Toxic Waste Management at the Samarinda City Environmental Agency

Running title: Hazardous Waste Management in Samarinda

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Abstract

Background: Hazardous and toxic waste (B3 waste) can pollute the environment and threaten human health when it is not managed in accordance with applicable requirements. **Objective:** To evaluate B3 waste management at the Samarinda City Environmental Agency against applicable regulations. **Methods:** A descriptive field-observation study assessed seven aspects: packaging, collection, storage, storage buildings, emergency-response facilities, symbols and labels, and transportation. Conformity was scored using a three-level Likert scale and converted to percentage achievement categories. **Results:** Collection and transportation achieved the highest conformity scores (100%; very good), followed by symbols and labels (86.2%; very good), packaging (77.7%; good), storage buildings (66.6%; fair), storage (62.5%; fair), and emergency-response facilities (36.6%; poor). Overall conformity was 75.65%, categorized as good. **Conclusion:** B3 waste management was generally good, but improvements are required in packaging, storage arrangements and facilities, emergency preparedness, and labeling compliance. **Keywords:** hazardous waste; toxic waste; B3 waste; waste management; environmental health

Research Highlights

- Overall conformity of hazardous and toxic (B3) waste management at the Samarinda City Environmental Agency was 75.65%, categorized as good.
- B3 waste collection and transportation showed full conformity (100%), whereas emergency-response facilities in the storage building had the lowest conformity (36.6%).
- Priority improvements involve packaging inspection and closure, block-based storage and facility upgrades, emergency preparedness, and complete symbols and labels.

1 Introduction

Environmental problems are important issues that need to be understood and studied, particularly because of the impacts they can generate. These impacts may be substantial and significant for the environment and the living organisms within it [1]. Waste-related problems have become an important concern for both the public and the Indonesian government, especially over the past three decades. This concern has been driven by growth in the industrial sector, which plays a major role in supporting national economic development. In response to the increasing volume and distribution of waste across sectors, various regulations have been issued to address waste management problems [2].

Based on Government Regulation of the Republic of Indonesia No. 22 of 2021 concerning the Implementation of Environmental Protection and Management, the environment is described as an integrated spatial unit encompassing all objects, including humans and their behavior, that influence nature, the continuity of life, and the welfare of humans and other living organisms [3]. This definition illustrates that environmental contamination may occur through multiple pathways, including human activities and the consequences of those activities [4].

Management of hazardous and toxic waste (B3 waste) in line with waste reduction, reuse, and recycling efforts is an important component of B3 waste management [5]. Because B3 waste requires special handling, appropriate regulatory requirements are needed for every management method, and each stage must be implemented properly to prevent adverse effects on humans, other living organisms, and the environment. Although regulations governing B3 waste are available, oversight by relevant parties remains necessary to ensure that the requirements are implemented in practice [6].

The Samarinda City Environmental Agency manages hazardous and toxic waste generated by the operation of municipal garbage-collection trucks and by office activities. In 2024, the agency generated 2,624.35 kg of B3 waste. The waste consisted of liquid waste, such as used lubricating oil, and solid waste, including used batteries, used vehicle batteries, and B3-contaminated packaging. The source manuscript reports that B3 waste management at the Samarinda City Environmental Agency had not previously been studied.

This study aimed to compare current B3 waste management conditions at the Samarinda City Environmental Agency - including packaging, collection, storage, storage buildings, emergency-response facilities in the storage building, symbols and labels, and transportation - with applicable regulatory requirements.

2 Materials and Methods

2.1 Study design and setting

The study was conducted at the Samarinda City Environmental Agency, located on Jl. MT. Haryono, Air Putih Urban Village, Samarinda Ulu District, Samarinda City, East Kalimantan, Indonesia. The field survey was conducted to obtain information on B3 waste management at the agency. A descriptive approach was used to

describe current B3 waste management conditions. Direct observation was used to document field conditions, and conformity was assessed using a Likert-type scoring system.

2.2 Population, sampling, and sample size

The population was defined as all municipal government offices in Samarinda City. The study sample was the office reported to generate the largest amount of B3 waste. The Samarinda City Environmental Agency was selected because it independently manages a fleet of garbage-collection trucks, thereby generating used lubricating oil, used vehicle batteries, and other B3 waste from operational and office activities.

2.3 Variables and measurements

Two types of data were collected: primary and secondary data. Primary data were obtained directly through field observation. Secondary data were obtained from the Samarinda City Environmental Agency. The assessed management aspects were B3 waste packaging, collection, storage, storage buildings, emergency-response facilities in the B3 waste storage building, B3 waste symbols and labels, and B3 waste transportation. Transportation outside the agency was undertaken in collaboration with a third party, as reported in the source manuscript.

2.4 Statistical analysis

The collected data were organized in tables and analyzed descriptively. Each aspect of B3 waste management was compared with the applicable regulations. The comparison was then scored to determine the degree of conformity using a three-level Likert scale. First, the observed condition of each B3 waste management component was compared with the relevant regulatory requirement after the assessment points had been defined. Second, the comparison was used to determine whether the current practice fulfilled the applicable requirements. Third, each degree of conformity for each parameter was assigned a score as shown in Table 1 [7].

Table 1. Conformity scoring levels

No.	Conformity level	Score
1	Non-conforming	1
2	Partially conforming	2
3	Conforming	3

Source: Defany (2023) [7]. Non-conforming = management is carried out without reference to applicable regulations; partially conforming = only part of the management process follows the established requirements; conforming = the entire management process follows applicable regulations and requirements.

The actual percentage score for each management component was calculated using the formula: actual percentage score = (actual score / ideal score) × 100%. The actual score represented the score obtained from comparison of B3 waste management practices with the relevant regulatory requirements, whereas the ideal score represented the highest possible score for implementation of the assessed activity. The resulting percentage was then interpreted using the achievement criteria shown in Table 2 [7].

Table 2. Criteria for percentage achievement of the actual score

No.	Actual score (%)	Criterion
1	≤20-36%	Not good
2	>36-52%	Poor
3	>52-68%	Fair

No.	Actual score (%)	Criterion
4	>68-84%	Good
5	>84-100%	Very good

Source: Defany (2023) [7]. Percentage intervals are reproduced from the source manuscript.

2.5 Ethical considerations

The source manuscript includes institutional research-permission documentation. A research permission request was issued by the Environmental Health Diploma Program, Faculty of Public Health, Universitas Muhammadiyah Kalimantan Timur (No. 420/FKM.3/C.5/B/2025, dated 19 February 2025), and the Samarinda City Environmental Agency granted research permission through letter No. 000.9/434/100.12 dated 3 March 2025. The study was based on facility observation and institutional data.

3 Results

3.1 Overall conformity of B3 waste management

Field observation at the Samarinda City Environmental Agency generated conformity scores for seven B3 waste management aspects (Table 3). B3 waste collection and transportation achieved the highest scores, both at 100%, indicating very good conformity with the applicable requirements. Emergency-response facilities in the B3 waste storage building received the lowest score, 36.6%, and were categorized as poor. The overall mean conformity score was 75.65%, categorized as good.

Table 3. Observed conformity of B3 waste management at the Samarinda City Environmental Agency

No.	Management aspect	Actual score (%)	Category
1	B3 waste packaging	77.7	Good
2	B3 waste collection	100.0	Very good
3	B3 waste storage	62.5	Fair
4	B3 waste storage building	66.6	Fair
5	Emergency-response facilities in the B3 waste storage building	36.6	Poor
6	B3 waste symbols and labels	86.2	Very good
7	B3 waste transportation	100.0	Very good
Mean		75.65	Good

Source: Processed primary data, 2025. B3 = hazardous and toxic materials; B3 waste refers to hazardous and toxic waste generated by the assessed activities.

4 Discussion

4.1 B3 waste packaging

The Samarinda City Environmental Agency packages B3 waste in accordance with the general purpose of applicable requirements by placing or containing B3 waste so that storage and transportation are easier and safer for the environment and human health. Packaging is differentiated according to waste type, so different B3 waste types are placed in different containers [8]. Separation of B3 waste containers according to waste characteristics is intended to prevent the mixing of wastes with different properties that could produce undesirable reactions [9].

Packaging practices at the Samarinda City Environmental Agency were not fully compliant with the requirements described in Regulation of the Minister of Environment and Forestry No. 6 of 2021. The agency inspected B3 waste packages only at the time of transportation. According to the regulation cited in the source manuscript, the person responsible is required to inspect B3 waste packages at least three times per day to ensure that the packages are not damaged or leaking [10].

The agency used plastic and metal drums to package solid and liquid B3 waste before placement in the temporary storage facility. This practice was intended to prevent environmental contamination, human exposure, and contact or mixing with other substances that could create additional hazards [3]. However, solid B3 waste packages were not tightly closed because their contents exceeded container capacity. Under Regulation of the Minister of Environment and Forestry No. 6 of 2021, B3 waste packages are required to remain tightly closed and should be opened only when waste is added or removed [10].

Based on the study results, the conformity of B3 waste packaging at the Samarinda City Environmental Agency with the relevant requirements was 77.7%, placing this aspect in the good category.

4.2 B3 waste collection

B3 waste collection is the process of gathering B3 waste generated by an activity before it is transferred to a B3 waste disposer or user [11]. Each activity that generates B3 waste is required to collect the waste it produces, and B3 waste collectors are required to hold the relevant waste-management authorization as described in Regulation of the Minister of Environment and Forestry No. 6 of 2021 [10]. At the Samarinda City Environmental Agency, containment of B3 waste had already begun in each waste-generating unit through the provision of dedicated B3 waste bins equipped with appropriate symbols.

After waste was placed in the provided containers, B3 waste was collected from each generating unit [3]. Mixing stored B3 waste was prohibited. For example, two types or two different characteristics of B3 waste were not permitted to be combined within a single package or container because incompatible waste mixing could produce hazardous reactions and, in severe circumstances, contribute to explosion risks [12].

Based on the study results, conformity of B3 waste collection at the Samarinda City Environmental Agency with the relevant requirements was 100%, categorized as very good.

4.3 B3 waste storage

After B3 waste was packaged and collected from its generating sources, it was stored in a temporary B3 waste storage facility. At the time of observation, the storage arrangement did not use a block system and there was no spacing between blocks. The source manuscript notes that a recommended B3 waste storage layout uses a block system with a 2 × 2 package arrangement [11]. The block arrangement functions as a separator to prevent different wastes from mixing. In addition, stored waste at the Samarinda City Environmental Agency was not placed on pallets, which would otherwise prevent direct contact between the packages and the floor. B3 waste storage is an important control intended to minimize risks to humans and the environment [13].

Based on the study results, conformity of B3 waste storage at the Samarinda City Environmental Agency with the relevant requirements was 62.5%, categorized as fair.

4.4 B3 waste storage building

Regulation of the Minister of Environment and Forestry No. 6 of 2021 concerning procedures and requirements for B3 waste management specifies that a temporary B3 waste storage building should have ventilation protected by mesh or other suitable material to prevent the entry of small birds. Lighting should be adequate for the room, and switches or electrical outlets should be installed outside the building. The storage

components should be separated by partition walls and containment barriers, and each storage area should have a waste-retention basin [7,10].

The B3 waste storage building at the Samarinda City Environmental Agency had not fully met these requirements. Ventilation was not fitted with mesh or other protective material. A lighting system was available but was not functioning optimally, and electrical outlets had not been installed outside the building. There were no partition walls between storage components. The package arrangement had not adopted a block or cell system; consequently, no aisles or containment barriers separated the packages, and the B3 waste packages were placed close together without adequate spacing [14].

Based on the study results, conformity of the B3 waste storage building with the relevant requirements was 66.6%, categorized as fair.

4.5 Emergency-response facilities in the B3 waste storage building

Each temporary B3 waste storage facility should be equipped with portable fire extinguishers, an emergency evacuation door, an alarm system, and other emergency-response equipment as part of environmental protection and management [15]. The Samarinda City Environmental Agency had a portable fire extinguisher, but it was not mounted on the wall of the temporary storage facility. The source manuscript notes that fire extinguishers are important because some B3 wastes are highly flammable [7]. The emergency-response facilities at the storage building were not equipped with a safety fence, backup power supply, first-aid facilities, communication equipment, or a dedicated storage area for emergency tools and supplies.

Emergency-response facilities must remain ready for use to anticipate unwanted and potentially hazardous events. At the Samarinda City Environmental Agency, the temporary B3 waste storage facility did not have an emergency door, alarm, lightning protection, or other emergency-response equipment. The source manuscript groups these provisions into emergency-response facilities and supporting facilities. Their availability in temporary B3 waste storage is important for protecting workers, occupational health and safety, and the surrounding environment [16].

Based on the study results, conformity of emergency-response facilities in the B3 waste storage building with the relevant requirements was 36.6%, categorized as poor.

4.6 B3 waste symbols and labels

Most symbol and label practices at the Samarinda City Environmental Agency met the applicable requirements. However, one deficiency remained: empty B3 waste containers or packages did not carry an "EMPTY" label. The source manuscript states that empty containers should display a 10 cm × 10 cm symbol with the word "EMPTY" in the center [17]. Symbols and labels on empty B3 waste packages are important for identifying potential waste hazards, such as toxicity, corrosivity, or flammability. They also provide information on the origin, type, and status of the waste, including the "EMPTY" marking to indicate that a container no longer contains waste. Such information helps prevent handling errors and supports waste management in accordance with procedures. The use of B3 waste symbols and labels is also described as a legal requirement under Regulation of the Minister of Environment No. 14 of 2013 [18].

Based on the study results, conformity of B3 waste symbols and labels with the relevant requirements was 86.2%, categorized as very good.

4.7 B3 waste transportation

Transportation of B3 waste at the Samarinda City Environmental Agency began with collection of waste from different generating points. Transportation was required to follow the applicable maximum storage periods. According to the source manuscript, category 1 waste generated at less than 50 kg per day may be stored for a

maximum of 180 days, whereas category 2 waste may be stored for up to one year. Category 1 waste is required to be transported using enclosed vehicles, whereas category 2 waste may be transported using either enclosed or open transportation facilities [19].

The Samarinda City Environmental Agency only conducted internal B3 waste transportation from individual rooms or generating units to the temporary storage facility. Transportation from the temporary storage facility to an external third party was carried out by a partner working with the agency. Each B3 waste shipment transferred from the temporary storage facility to a utilization or management facility was required to be accompanied by an official B3 waste document. This documentation contains information that must be completed by both the B3 waste generator and the waste transporter [20].

Based on the study results, conformity of B3 waste transportation at the Samarinda City Environmental Agency with the relevant requirements was 100%, categorized as very good.

5 Conclusion

B3 waste management at the Samarinda City Environmental Agency comprised packaging, collection, storage, storage-building management, emergency-response facilities in the storage building, symbols and labels, and transportation. The overall conformity score was 75.65%, categorized as good. Among the seven assessed aspects, B3 waste collection and transportation achieved the highest conformity scores (100%; very good), whereas emergency-response facilities in the B3 waste storage building received the lowest score (36.6%; poor). Improvements should prioritize B3 waste packaging, storage arrangements, the B3 waste storage building, emergency-response facilities, and the completeness of B3 waste symbols and labels to strengthen environmental and human-health protection.

6 Declarations

Ethics approval and consent to participate

The source manuscript documents institutional research permission from the Samarinda City Environmental Agency (Letter No. 000.9/434/100.12, 3 March 2025), following a research permission request from Universitas Muhammadiyah Kalimantan Timur (No. 420/FKM.3/C.5/B/2025, 19 February 2025).

Consent for publication

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Competing interests

The authors declare that they have no financial or non-financial competing interests that could have influenced the work reported in this study.

Author contributions (CRediT)

Husnul Mar'iyah: Conceptualization, Methodology, Investigation, Data Curation, Formal Analysis, Visualization, and Writing – Original Draft.

Vita Pramaningsih: Conceptualization, Methodology, Supervision, Validation, and Writing – Review & Editing.

Deny Kurniawan: Methodology, Supervision, Validation, and Writing – Review & Editing.

All authors reviewed and approved the final version of the manuscript.

Data availability

The data supporting the findings of this study consist of field observation data and relevant records obtained from the Samarinda City Environmental Agency. The data are available from the corresponding author upon reasonable

request and, where applicable, subject to permission from the Samarinda City Environmental Agency and applicable institutional data-access policies.

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Generative AI statement

Generative AI was used to assist with English-language translation, structural reorganization, and manuscript formatting. The authors reviewed the output and remain responsible for the accuracy, originality, citations, and integrity of the manuscript.

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