Design of an Integrated Temporary Storage for Hazardous and Toxic Material Wastes 4.0 Case Study in The Department of Industrial Chemical Engineering

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Abstract

The Department of Industrial Chemical Engineering is one of the departments within the Faculty of Vocation at Institut Sepuluh Nopember Surabaya (ITS). It has four laboratories. The activities conducted in these laboratories, both in terms of practical work and research, generate hazardous and toxic waste that should be stored in a temporary waste storage facility. Temporary storage is crucial for safely containing hazardous and toxic Hazardous waste until it can be properly processed, disposed of, or transported to a permanent storage location. The primary goals of this facility are containment, separation, safety, and compliance with environmental regulations. The design and features of the facility play a crucial role in ensuring the effectiveness of temporary storage. Secondary containment structures, chemical compatibility measures, ventilation systems, safety protocols, and emergency response equipment are the primary components of this facility. These elements work together to prevent leaks, control chemical reactions, disperse hazardous vapours, maintain safety, and enable rapid emergency response. This research provides knowledge on the design of temporary storage facilities for hazardous and toxic materials, with technical specifications following regulations. Effective temporary storage management can protect human health and the environment and promote sustainable waste management practices.

Keywords: B3; Temporary waste storage; Waste

1. Introduction

Waste is unused material or substances that can have negative impacts on society if not properly managed. Waste can be the byproduct of both natural processes and human activities. According to Government Regulation Number 101 of 2014, hazardous and toxic materials are substances, energy, and/or quantities that, either directly or indirectly, can pollute or damage the environment, human health, and the sustainability of human and other living beings. Hazardous and toxic waste, on the other hand, refers to the byproducts of an enterprise and/or activity that contain hazardous and toxic materials [1][2].

One of the sources of hazardous and toxic waste is laboratories, which are places where testing activities are conducted, whether related to practical work or research, to obtain accurate test data. Common chemicals used for testing in laboratories include acidic, basic, organic, and inorganic chemicals. These materials are typically disposed of, resulting in laboratory waste [3]. Laboratory waste can be categorized as hazardous and toxic waste. Hazardous and toxic waste generated by laboratories in the Department of Industrial Chemical Engineering is classified as specific waste, and hazardous and toxic waste can further be grouped based on their physical and chemical properties. The physical properties of hazardous and toxic waste consist of solid and liquid waste, while based on their chemical properties, hazardous and toxic waste can be classified as organic hazardous and toxic waste and inorganic hazardous and toxic waste [4].

The laboratory in the Department of Industrial Chemical Engineering generates more hazardous and toxic waste in liquid form. As environmental awareness continues to increase, proper management of hazardous waste becomes increasingly important. Temporary storage facilities play a vital role in ensuring the safe containment and handling of waste until it can be properly processed, disposed of, or transported to a permanent storage location. Currently, the Department of Industrial Chemical Engineering does not have a temporary storage facility for hazardous and toxic waste, so there is a need to design a temporary storage building for hazardous and toxic waste that complies with regulations.

1.1. Purpose of Temporary Storage

Temporary storage facilities are designed to meet several objectives, including [5]:

a. Containment: These facilities are equipped to securely hold hazardous and toxic waste, preventing any leakage or spills that could harm the environment or human health.
b. Segregation: Waste is sorted and stored according to its characteristics, such as flammability, toxicity, or reactivity, to minimize the risk of chemical reactions that could result in accidents or releases.
c. Safety Measures: Temporary storage sites implement safety protocols and procedures to ensure the well-being of workers, surrounding communities, and the environment.
d. Compliance: These facilities must adhere to strict regulations and guidelines set by environmental agencies to ensure proper waste management and minimize the potential for negative impacts.

2. Method

This research method uses a descriptive qualitative method. Descriptive qualitative research is a study designed to provide a systematic and accurate description of the situation that is the subject of the research [6].

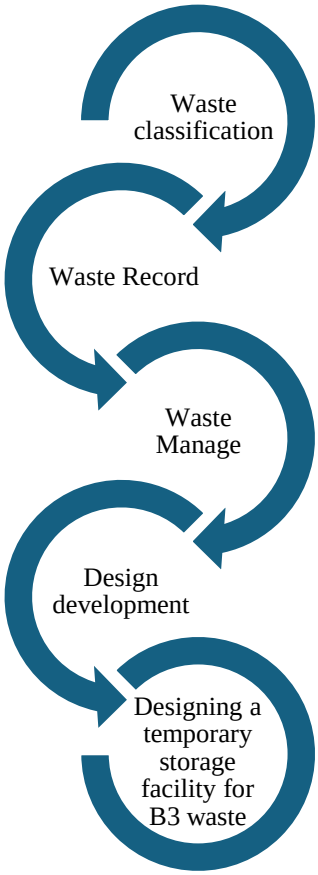

Figure 1. Research Methodology

3. Results and Discussion

3.1. Identification of Hazardous and Toxic Waste

Before hazardous and toxic waste is handed over to waste handlers, waste identification must be conducted. Based on Government Regulation Number 101 of 2014, the identification of hazardous and toxic waste is differentiated into two methods, based on characteristic testing and toxicity testing [7]. The determination of hazardous and toxic waste consists of two categories [8]:

a. Hazardous and toxic waste that is acute and directly impacts humans and the environment.
b. Hazardous and toxic waste that has delayed effects and does not directly impact humans and the environment.

Labeling on storage and collection containers for each hazardous and toxic waste is a crucial factor in maintaining safety. This labeling aims to provide fundamental information about the type and characteristics of the

waste [9]. According to the Minister of Environment Regulation Number 14 of 2013, labeling serves to provide information regarding the origin, identity, and quantity of hazardous and toxic waste [10]. The symbols for hazardous and toxic waste affixed to containers must adhere to the following provisions [9]:

a. The type of symbol for hazardous and toxic waste must correspond to the characteristics of the contained waste.
b. Symbols should be affixed on the side of the container that is easily visible.
c. Symbols for hazardous and toxic waste must not be removed, replaced, or changed with different symbols before the container or packaging is emptied.

3.2. Management of Hazardous and Toxic Waste

The management of hazardous and toxic waste as Government Regulation Number 101 of 2014 involves activities including reduction, storage, collection, transportation, utilization, processing, and disposal of hazardous and toxic waste [8]. The purpose of managing hazardous and toxic waste is to prevent and mitigate environmental pollution or damage caused by such waste, and to restore the quality of the contaminated environment to its original state, ensuring it functions properly (Minister of Environment Regulation Number 30 of 2009 regarding Procedures for Licensing and Supervision of the Management of Hazardous and Toxic Waste and Supervision of Recovery from Pollution Caused by hazardous and toxic waste by the Government) [11].

a. Reduction of Hazardous and Toxic Waste
   The reduction of hazardous and toxic waste involves activities to decrease the amount and/or reduce the hazardous and toxic properties of B3 waste before it is generated from a specific activity or endeavor.
b. Storage of Hazardous and Toxic Waste
   Storage of hazardous and toxic waste involves the temporary containment of hazardous and toxic waste by its generator for the purpose of storing the hazardous and toxic waste it produces.
c. Collection of Hazardous and Toxic Waste
   Collection of hazardous and toxic waste involves gathering hazardous and toxic waste from its source before it is handed over to handlers, processors, and/or storage facilities for hazardous and toxic waste.
d. Transportation of Hazardous and Toxic Waste
   Transportation of hazardous and toxic waste involves the movement of hazardous and toxic waste by business entities.
e. Utilization of Hazardous and Toxic Waste
   Utilization of hazardous and toxic waste involves the reuse, recycling, and/or recovery aimed at transforming hazardous and toxic waste into products that can be used as substitutes for raw materials, auxiliary materials, and/or safe fuel for human health and the environment.
f. Processing of Hazardous and Toxic Waste
   Processing of hazardous and toxic waste involves the procedures to diminish and/or eliminate the hazardous and toxic properties.
g. Disposal of Hazardous and Toxic Waste
   Disposal of hazardous and toxic waste involves the placement of hazardous and toxic waste in storage facilities with the intention of not endangering human health and the environment.

3.3. Temporary Storage Facility for Hazardous and Toxic Waste

Temporary storage facilities for hazardous and toxic waste are essential to prevent the contamination of the surrounding environment, as such waste can have adverse effects on human health and the nearby ecosystem [12]. According to Government Regulation Number 30 of 2009 regarding the requirements for the construction of Temporary Storage Facilities for Hazardous and Toxic Waste, the following aspects must be considered [13]:

a. The facility must have a design and storage space area suitable for the type, characteristics, and quantity of hazardous and toxic waste being stored.
b. The building should have a non-flammable roof and adequate air ventilation.
c. It must be shielded from direct or indirect exposure to rainwater.
d. The facility needs to have adequate lighting (either artificial or natural sunlight).

e. The floor should be waterproof, level, strong, and free from cracks.
f. Walls should be constructed from non-flammable materials.
g. The building should be equipped with appropriate symbols for identification.
h. Installation of lightning rods is required if necessary.

3.4. Facility Design and Features

Temporary storage sites for hazardous and toxic waste typically incorporate the following design elements and features [5][12]:

a. Secondary Containment: Facilities are constructed with containment structures, such as berms or dikes, to contain any potential spills or leaks within the designated storage area.
b. Chemical Compatibility: Storage areas are designed to prevent incompatible waste materials from coming into contact with each other, reducing the risk of chemical reactions and accidents.
c. Ventilation Systems: Adequate ventilation is provided to control and disperse hazardous vapors, preventing the buildup of toxic gases within the storage area.
d. Security Measures: Facilities employ security protocols, such as restricted access, surveillance systems, and alarms, to prevent unauthorized entry and ensure the safety of the stored waste.
e. Emergency Response Equipment: Temporary storage sites are equipped with emergency response equipment, including spill containment kits, fire suppression systems, and personal protective equipment, to address any potential incidents swiftly and effectively.

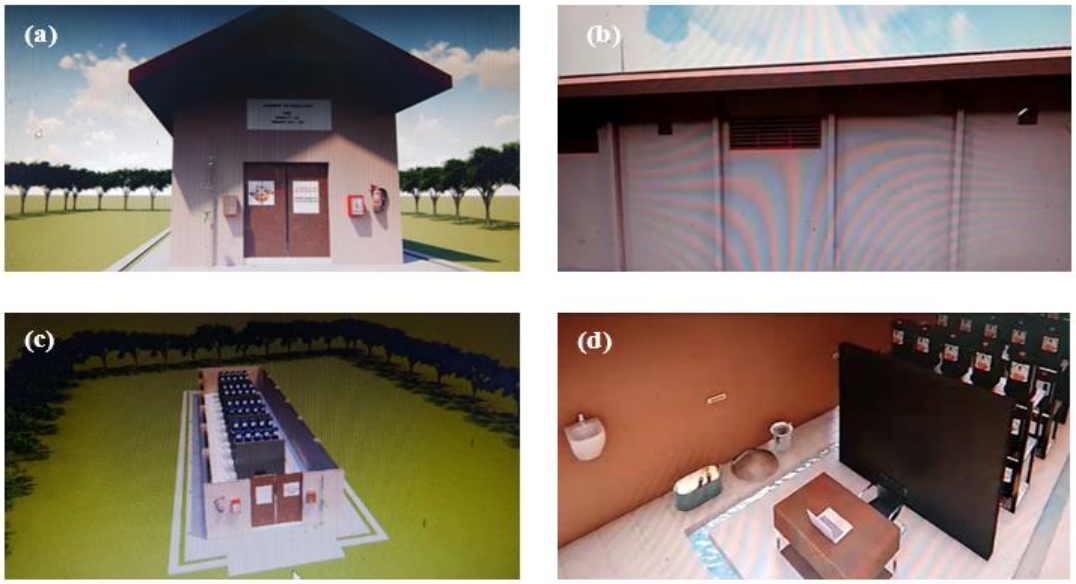

Figure 2. Front view of Temporary Storage Facility Design (a), Side View of the Temporary Storage Facility Design (b), Interior View of the Temporary Storage Facility Design (c), Detailed interior view of the temporary storage facility design (d)

The picture shows a temporary storage structure constructed with non-combustible bricks to prevent the risk of erosion during rainfall. Additionally, on the front side of the building, several tools are provided to minimize the risk of disasters, including:

a. Shower/eye wash
b. Personal Protective Equipment
c. Portable Fire Extinguisher
d. First Aid Kit
e. Hazardous and Toxic Waste Symbol

The image above shows a temporary storage facility building equipped with a good ventilation system and lightning protection, which helps minimize the risk of hazards during rainy weather accompanied by lightning.

In the above image, there are several shelves for storing hazardous and toxic waste, where each shelf and jerrycan are distinguished based on the waste's characteristics. Additionally, each waste container is labeled with hazardous and

toxic waste symbols, aiming to facilitate users and minimize the risk of mixing waste with different characteristics. Inside the temporary storage facility, there are also containment trays or water drainage areas used for managing waste spills. Additionally, sawdust and sand are present for handling waste spills.

4. Conclusions

Temporary storage places for hazardous and toxic waste serve as crucial intermediate points in the lifecycle of such materials. By following strict regulations, employing appropriate facility design, and implementing safety measures, these facilities help ensure the containment and safe handling of hazardous waste. Effective management of temporary storage is vital for protecting human health, the environment, and promoting sustainable waste management practices.

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