SIMETRIKAL
Journal of Engineering and Technology

Analysis of the Storage of Solid Medical Hazardous and Toxic Waste (B3) in Enhancing the Performance of Type C Hospitals: A Case Study at Universitas Sumatera Utara Hospital

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Abstract. [The Universitas Sumatera Utara Hospital's waste management system, based on Regulation 56 of 2015, has been criticized for unsanitary conditions and lack of proper waste labeling. A study focusing on three locations revealed that the majority of B3 waste originates from infectious properties and sharp objects. The hospital's waste management involves segregating waste based on its characteristics, using appropriate containers, and transporting it to the B3 waste Temporary Storage for storage. The hospital is implementing a multi-stage approach to manage B3 waste, including sorting, containerization, internal transportation, and storage. The waste is segregated and contained within designated containers, transported daily using trolleys or wheeled containers, stored in facilities shielded from direct sunlight, and designed to prevent access by animals, insects, and birds. Regular cleaning is also essential. The hospital aims to improve waste management efficiency by implementing proper waste disposal, packaging, and transportation.]

Keyword: [Efficiency, Hazardous and Toxic, Hospital, Management, Waste]

Abstrak. *[Sistem pengelolaan limbah Rumah Sakit Universitas Sumatera Utara berdasarkan Peraturan Menteri Lingkungan Hidup Nomor 56 Tahun 2015 mendapat kritik karena kondisinya yang tidak sehat dan tidak adanya label limbah yang tepat. Kajian yang dilakukan di tiga lokasi menunjukkan bahwa sebagian besar limbah B3 berasal dari bahan infeksius dan benda tajam. Pengelolaan limbah rumah sakit meliputi pemilahan limbah berdasarkan karakteristiknya, penggunaan wadah yang sesuai, dan pengangkutannya ke Tempat Penyimpanan Sementara limbah B3 untuk disimpan. Rumah sakit menerapkan pendekatan multi-tahap dalam pengelolaan limbah B3, termasuk pemilahan, kontainerisasi, transportasi internal, dan penyimpanan. Sampah dipisahkan dan ditampung dalam wadah yang telah ditentukan, diangkut setiap hari menggunakan troli atau wadah beroda, dan disimpan di fasilitas yang terlindung dari sinar matahari langsung dan dirancang untuk mencegah akses oleh hewan, serangga, dan burung. Pembersihan rutin juga penting. Rumah sakit bertujuan untuk meningkatkan efisiensi pengelolaan limbah dengan menerapkan pembuangan, pengemasan, dan transportasi limbah yang benar.]*

Kata Kunci: *[Efisiensi, Berbahaya dan Beracun, Rumah Sakit, Pengelolaan, Limbah]*

Received 30 August 2023 | Revised 17 June 2024 | Accepted 31 July 2024

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1 Introduction

Hospital B3 (hazardous and toxic) medical waste can be considered a link in the chain of spreading infectious diseases. Waste can become a place for disease organisms to accumulate and nest for insects, mice, and other animals. Apart from that, waste also contains various toxic chemicals and sharp objects that can cause health problems and injuries [1]. Based on data from the Ministry of Health, 290 tons of medical waste is generated by health service facilities in Indonesia every day. On June 24, 2020, the Minister of Environment and Forestry said that the medical waste produced by the island of Sumatra during the COVID-19 pandemic was 147.62 tons [2].

Of the 199 hospitals in North Sumatra, only 31 hospitals carry out medical waste management [3]. The results of monitoring and supervision by 4 (four) Regency/City Environmental Services in 13 District Hospitals and 20 Private Hospitals in North Sumatra, show that the amount of infectious B3 waste generated by Covid-19 from Health Facilities was 27,452.15 kg. Of this amount, 47% was burned using an incinerator, 31% was handed over to third parties, and 22% was stored in the B3 Waste TPS.

As time goes by, the amount of waste increases day by day [4]. Effective management of medical waste is crucial to prevent the escalation of these quantities. Hospital B3 waste handling must pay attention to the principles of hospital B3 waste management. Efforts that must be made are identifying the type of B3 waste, paying attention to the stages of the process of handling the container and transport of B3 waste in the source room, how to reduce and sort B3 waste, the condition of the TPS building in the hospital, temporary storage of B3 waste, the length of time the B3 waste is stored for types of waste characterized by infectious, sharp and pathological objects in hospitals before being transported, how to transport B3 waste, and how to process B3 waste [5].

Universitas Sumatera Utara (USU) Hospital is a type C hospital that prioritizes the quality of health services [6]. In the process of providing medical services to the community, USU Hospital directly produces solid waste from medical services. USU Hospital produces approximately 150 kg of medical waste per day and the most dominant medical waste is Personal Protective Equipment in the form of hazmats, gloves, and masks during pandemic conditions. The medical waste generated in a month can reach 1.5 – 2 tons. The generation of medical waste is caused by the number of patients increasing every day [7].

Therefore, it is necessary to evaluate the management of B3 waste implemented at USU Hospital. The evaluation of B3 waste management aims to collect data related to the B3 waste management process and compare it with applicable standards or statutory regulations to determine the effectiveness of the B3 waste management process that has been implemented to increase the optimization of B3 waste management performance at USU Hospital.

2 Research Method

This research was conducted in December 2022 at USU Hospital. The objects to be studied include the sources of B3 waste production, the characteristics of B3 waste, and the stages of B3 waste management at USU Hospital which include sorting, containerization, internal transportation, and storage. The type of research used is descriptive research using qualitative methods. Descriptive research aims to find and explain a problem by describing certain objects in depth and detail [8]. Meanwhile, the qualitative method is used to collect data based on research results and provide general conclusions regarding the research object in the form of words, sentences, and narrative expressions based on the data used. Qualitative methods are descriptive and tend to use analysis, so qualitative research results require researchers to be able to analyze the data obtained in depth [9].

The data collection techniques are observation, interview, and documentation. The research instruments include observation guidelines, questionnaires, interviews, handphone, and digital camera. The selection of informants was carried out using purposive sampling technique which used the Slovin formula to determine the number of informants. The data obtained will be subjected to data reduction, data comparison, data determination, and evaluation. This is done by comparing the B3 waste storage process with the criteria contained in the Minister of Environment and Forestry Regulation Number 56 of 2015 concerning Procedures and Technical Requirements for Management of Hazardous Waste and Toxic Hazardous Materials (B3) from Health Service Facilities [10].

3 Results and Discussion

Solid waste is grouped into 4 types, namely cytotoxic, pharmaceutical and B3 waste, infectious and sharp objects. Hospital waste is waste originating from hospital activities in the form of solid, liquid, paste (gel), or gas which is infectious, radioactive and toxic chemicals [11]. The USU Hospital conducted a study on the sources of solid medical B3 waste. The study focused on three sample locations within the hospital, namely the emergency department, inpatient installation, and clinical laboratory installation. The solid medical waste classified as B3 exhibited similar types and features across the three sampling locations.

Based on the analysis of origins and attributes of B3 waste, it is evident that the majority of B3 waste originated from three distinct sample sites, specifically waste exhibiting infectious properties and including sharp objects. Out of the six attributes of B3 waste that were investigated, it was observed that two specific attributes, namely pharmaceutical waste and expired chemicals, were absent.

3.1 Effective Management of Medical Hazardous Waste at USU Hospital

The management of solid medical B3 waste involves a series of steps that begin at the point of origin when solid medical B3 waste is generated. In every room, there was a receptacle for solid medical B3 waste with infectious waste characteristics, which was enclosed in a yellow plastic bag. In the context of sharp waste management, safety boxes were made available to facilitate the disposal of various items such as syringes, glass slides, vials, ampoules, and similar materials. When the waste reaches its maximum capacity within the designated storage containers, the cleaning service proceeds to gather it using a cart that is conveniently stationed on each floor of the hospital. Subsequently, the waste present in the trolley is conveyed by the cleaning personnel using the B3 waste transporter, and subsequently transferred to the B3 waste Temporary Storage (TPS LB3) where it is securely stored for six days. Following this period, the waste is then delivered by an external transporter.

A. Sorting

In the management of solid medical B3 waste, a common practice involves the segregation of waste based on its characteristics. This entails the use of distinct containers or packaging designated for B3 waste and non-B3 waste, respectively. The segregation of medical B3 waste is shown in Figure 1.

Figure 1. Segregation of Medical B3 Waste

B. Container

The process of containerizing solid medical B3 waste involves the provision of appropriate packaging or containers within all facility areas generating such waste, taking into account the specific characteristics of the B3 waste being produced. Containers constructed of PVC polyester are commonly used for infectious waste, whereas sharps waste is typically stored in t-liter and 12.5 liter safety boxes.

C. Internal Freight

Internal transportation is carried out three times a day based on changing working hours: morning, afternoon, and evening. The internal transportation route is carried out sequentially starting from the area that is furthest to the closest to the location of the B3 Waste TPS, namely from the 4th floor to the 1st floor in each room or installation that produces solid medical B3 waste, and will be collected to the B3 Waste Temporary Storage. TPS LB3 using the wheeled trolley. The trolley

is made of fiberglass, which is strong and easy to clean. The internal transport process is shown in Figure 2.

Figure 2. The Internal Transport Process of Medical B3 Waste to TPS

Following the process of internal transportation, it is necessary to cleanse the wheeled trolleys by employing a combination of water and detergents. The waste transportation equipment of category B3 undergoes daily cleaning by designated cleaning personnel. Subsequently, the wheeled trolley was transported to the designated chamber housing the inventory of cleanliness. There were a total of ten trolleys that were made available within the hospital setting.

D. Storage

The Temporary B3 Waste Storage Site (TPS LB3) was utilized for the storage of solid medical B3 waste for a duration of 6 days. The solid medical waste kept in TPS LB3 exhibits several distinct characteristics, including infectious properties, the presence of sharp objects, residual packaging materials, pharmaceutical waste, and contamination with B3 substances. The storage container for solid medical B3 waste at TPS LB3 was a cart equipped with three wheels. In accordance with proper medical waste management protocols, solid medical waste classified as B3 should be securely contained within a mobile trolley and encased in yellow plastic bags. Medical B3 waste storage containers are shown in Figure 3.

Figure 3. Medical B3 Waste Storage Containers

Evaluation of Storage of Medical B3 Waste in TPS at USU Hospital based on Minister of Environment and Forestry No. 56 of 2015. The evaluations are shown in Table 1 and Table 2.

Table 1. Criteria for Appropriate Medical B3 Waste Management

No.	Minister of Environment and Forestry regulations No. 56 of 2015	Realization at the University of North Sumatra Hospital
1	The location for storing B3 waste is stored in a flood-free area and is not prone to natural disasters.	The TPS LB3 location is a flood-free area that is not prone to natural disasters.

2	B3 Waste storage facilities are easily accessible for waste storage.	TPS LB3 is easily accessible to the cleaning staff when storing B3 waste.
3	B3 waste storage facilities are easily accessible to vehicles that collect or transport waste.	The LB3 TPS area is easily accessible to B3 waste transport vehicles.
4	B3 waste storage facilities are protected from sunlight, rain, strong winds, floods, and other factors that can cause work accidents or disasters.	TPS LB3 is protected from sunlight, rain, strong winds, floods, and other disasters that can damage or destroy the TPS LB3 facility.
5	The B3 waste storage facility is far from where food is stored or prepared.	The TPS LB3 area is far from the place where food is stored or prepared at the hospital.
6	The storage of B3 waste generated from health service facilities by producers of B3 waste should be carried out in a separate building from the main building of the health service facility.	The TPS LB3 building is located separately from the main healthcare facility or hospital building.
7	The storage location must be fixed away from the patient rooms, laboratories, operating rooms, or areas accessible to the public.	TPS LB3 locations remain far from the patient rooms, laboratories, operating rooms, or areas that can be accessed by the public.
8	B3 waste storage facilities include impermeable floors and concrete or cement floors with good drainage systems and are easy to clean and disinfect.	The floor of TPS LB3 is made of concrete or cement, which is impermeable (impermeable floor), and the outside is equipped with drainage around TPS LB3.
9	The B3 waste storage facilities were provided with a water source or tap water for cleaning.	TPS LB3 is equipped with a water faucet, which is used for cleaning the TPS LB3 and LB3 transportation equipment.
10	B3 Waste storage facilities can be locked to prevent access by unauthorized parties.	TPS LB3 can be locked to prevent access by unauthorized outsiders.
11	B3 waste storage facilities are equipped with adequate ventilation and lighting.	The TPS LB3 is equipped with ventilation for lighting and air circulation.
12	Cleaning equipment, protective clothing, and waste containers or bags should be located as close as possible to the storage facility location.	The cleaning equipment was located outside TPS LB3. Meanwhile, the B3 waste container was located inside the TPS LB3.

Table 2. Inappropriate Medical B3 Waste Management Criteria

No.	PERMEN LHK Criteria No.56 of 2015	Realization at the University of North Sumatra Hospital
1	B3 Waste storage facilities are not accessible to animals, insects, and birds.	Inside the B3 waste storage facility or TPS LB3, there are animals, such as rats and cockroaches.
2	Walls, floors, and ceilings of storage facilities were kept clean, including daily floor cleaning.	The walls, floors, and ceilings of TPS LB3 were dirty and had not been thoroughly cleaned inside or outside TPS LB3.

3	The storage locations were marked as follows.	There is no sign or description in the picture beside the TPS LB3.
4	Infectious waste, sharps, and/or pathological waste should not be stored for more than 2 (two) days to avoid bacterial growth, putrefaction, and odor.	Infectious waste and sharps are stored for more than two days, namely, for six days or almost one week.
5	If infectious waste, sharps, and/or pathological waste are stored for more than 2 (two) days, the waste must be chemically disinfected or stored in a refrigerator or cooler at a temperature of 0 ℃ or lower.	Infectious waste and sharp objects stored in TPS LB3 are stored for more than two days and are not subjected to chemical disinfection or stored in a refrigerator (cold room).
6	B3 waste must be stored in packaging with clear symbols and labels.	The hazardous waste stored in the packaging is accompanied by the LB3 symbol; however, there is no LB3 label on the package.
7	With the exception of sharps and liquid waste, B3 waste from health service facility activities is generally stored in plastic packaging, containers that have been given waste plastic, or packaging with certain standards, such as leak-proof.	B3 waste from health service facility activities is stored in plastic packaging; however, containers for storing B3 waste are not covered with plastic or standard leak-proof packaging.
8	All medical waste must be stored and collected in a temporary storage location until it is transported to the processing location.	Not all waste is stored at TPS LB3 until it is transported by a third party to the B3 waste processing location.
9	Example of B3 waste storage facility from a healthcare facility in a room equipped with access barriers (cages).	The TPS for B3 waste is not equipped with access barriers (cages), as shown in the picture below.
10	An example of a cold room for storage of B3 waste in the form of infectious waste, sharp objects and/or pathological within more than 48 (forty eight) hours since the B3 waste is generated.	There is no cold room for storing B3 waste with the characteristics of infectious waste, sharps, or pathological waste. A new cold room is designed and built in 2023.

Management of B3 medical waste at USU hospital has been carried out but is still not following requirements. The practice of storing B3 waste still does not meet the criteria. Based on the evaluation results of the storage of B3 waste at the B3 waste TPS, out of a total of 26 evaluation criteria, 10 criteria do not follow the Minister of Environment and Forestry Regulation Number 56 of 2015.

The results of this study are similar to Zein et al. and Pertiwi's research, namely that the cleanliness of temporary shelters (TPS) is not maintained. Several aspects of storing B3 waste in temporary shelters (TPS) do not meet the requirements and are very concerning. The buildings give the impression that they were built haphazardly without paying attention to the requirements for medical waste TPS. There are even several TPS that do not have special buildings and waste is

stored in public warehouses. Apart from that, these buildings are not equipped with necessary facilities such as cold storage for storing infectious medical waste, sinks, water taps, and emergency response equipment [12]-[13]. At the time of storage, the packaging waste was not equipped with labels. The problem of temporary storage of medical waste is caused by the perception that Community Health Centers are only trying to fulfill all the requirements when an accreditation assessment is to be carried out. When the accreditation assessment process is complete, the sorting conditions are no longer a serious concern and have not been carried out optimally [12].

3.2 Efforts to Enhance the Efficiency of Medical B3 Waste Management at USU Hospital

1. The process of arranging items in a specific order based on certain criteria
   a) The responsibility for segregating solid medical B3 waste is with the waste producer.
   b) Proper execution of package placement and labeling is crucial.
   c) Implementing a practice of arranging packages or containers in close proximity to separate contagious waste from non-infectious (domestic) waste, hence enhancing waste segregation.

2. Container
   a) The waste should be appropriately segregated and contained within a designated container or bag, in accordance with its respective waste type.
   b) The waste container or bag should not be filled to its maximum capacity, as it is recommended to leave around 3/4 of the container's volume unoccupied.
   c) Compaction or manual compression of waste within waste containers or bags using hands or feet is not recommended.
   d) Multiple waste containers or bags should be employed in instances where there is a leakage, tear, or incomplete closure of the waste container or bag.
   e) Each waste bag is required to be provided with symbols and labels that correspond to the specific category of waste.
   f) It is imperative to promptly substitute each waste bag or container with a new one following its disposal.

3. Internal Freight
   a) The transportation of waste on a daily basis at the minimum level.
   b) The transportation of waste within a facility shall be conducted between rooms whenever there is a change in the duty officer.
   c) The transportation of waste at the health service institution can be facilitated through the utilization of a trolley or wheeled container that possesses attributes of simple cleanability.
   d) Personnel responsible for waste transportation are required to possess clothing that adheres to occupational safety and health regulations.

e) Internal carriers are implemented using transportation timetables that are organized according to certain routes or zones.
f) It is recommended that the internal transport route commence from the furthest area and proceed towards the waste storage location in close proximity.

4. Storage
   a) B3 waste storage facilities are shielded from direct sunshine, precipitation, high winds, and inundation.
   b) The B3 waste storage facility offers convenient accessibility for waste storage, featuring lockable provisions and easy vehicular access for waste transportation.
   c) The recommended storage duration for solid medical waste classified as B3 should not exceed 2 or 48 hours. Chemical disinfection should be conducted for a duration exceeding 48 hours, or alternatively, the disinfectant should be appropriately stored in a refrigerator or cooler set at a temperature of 0 degrees Celsius.
   d) Waste storage facilities of type B3 are equipped with various essential features, including ventilation systems, drainage mechanisms, water taps, and emergency response equipment such as fire extinguishers and first-aid kits.
   e) B3 waste storage facilities are designed to prevent access by animals, insects, and birds.
   f) The B3 waste storage facility is situated at a considerable distance from areas designated for food storage or preparation.
   g) The cleanliness of storage facilities is maintained by ensuring that the walls, floors, and ceilings are regularly cleaned. This includes daily floor cleaning.

Although medical waste is not yet properly managed and safely disposed of in many countries, there are potential solutions that can address the challenges of medical waste in many countries with economies in transition. This mainly depends on the acceptance and funding of advanced technologies for medical waste treatment and the adaptation of sustainable concepts used in many developing and industrialized countries. The first step to proper medical waste management is source reduction (i.e. minimizing waste production), and proper segregation at source [14].

Experts have highlighted several issues in dealing with hazardous medical waste, such as (1) barriers in implementing proper medical waste management, including limited documentation regarding waste production, handling, and disposal, as well as planning and training failures, particularly in developing countries [15], (2) the lack of established waste segregation and handling in many hospitals and health centers, indicating the need for activation and enforcement of medical waste legislation [16], (3) the role of pharmaceutical waste management in collecting and disposing of community drug waste [17] and sensitizing the public on the importance of proper drug waste disposal [18], (4) evaluation of hazardous medical waste generation from different categories of healthcare facilities [19], and (5) developing an integrated framework for medical waste management [20]-[21].

The use of Personal Protective Equipment (PPE) is necessary as protection for workers in managing solid medical waste. The type of PPE used depends on the risk of solid medical waste produced and can protect workers from exposure to body fluids and blood, and minimize the possibility of scratches, punctures, and cuts. The PPE equipment for medical solid waste management officers is placed in a special PPE cupboard. The cupboard is in front of the officer's room and close to the TPS. Workers can use PPE such as aprons and gloves [22]-[23].

It is necessary to increase the role of hospitals in monitoring and evaluating the management of B3 medical waste and providing the use of PPE to waste officers. Regional governments can also participate in improving the management of B3 waste by building regional cluster-based transfer depots (transit) for B3 medical waste and making efforts for hospitals to process B3 medical waste sourced from small hospitals, health centers, clinics, and other health facilities based on city/regency [24].

4 Conclusion

Solid medical B3 waste at the USU Hospital, sourced from the emergency department, inpatient facility, and clinical laboratory, comprises infectious materials, sharp objects, packaging residues, and B3-contaminated waste. The hospital employs a multi-stage treatment approach involving sorting, containerization, internal transit, and storage. Evaluation against Ministry of Environment and Forestry regulations revealed discrepancies in 10 out of 26 criteria, constituting 38% of total criteria, while 16 were compliant. To improve efficiency, segregation should be integrated into containerization, transit, and storage processes. Proper disposal mandates use of designated containers labeled with B3 symbols, transported via wheeled trolleys, and stored at Temporary Storage Facilities for 2 to 48 hours.

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