e-ISSN 2581-0405
Asian Journal of Applied Research for Community Development and Empowerment
Journal home page: http://ajarcde-safe-network.org ISSN 2581-0405

Redesign Layout of the Hazardous Waste Storage Area for the Medical Device Manufacturing Industry

Mohammad Ferry Firmansyah[1] *and Aulia Ulfah Farahdiba*[2.]

[1] *Environmental Engineering Department, Faculty of Engineering and Science, UPN Veteran Jawa Timur, Indonesia,*

ARTICLE INFO

Article History:
Received: 23 November 2025
Final Revision: 07 December 2025
Accepted: 20 December 2025
Online Publication: 28 December 2025

KEYWORDS

Hazardous Waste, Layout, Regulations, Compatibility, Packaging

CORRESPONDING AUTHOR

*E-mail: 22034010062@student.upnjatim.ac.id

A B S T R A C T

Hazardous waste is waste generated by a business or activity that has chemical, physical, or biological characteristics that pose a danger to human health and the environment. The medical device manufacturing industry generates hazardous waste, including used lubricating oil, used rags, product rejects, and fluorescent lamp electronic waste. This industry already has a hazardous waste storage facility that temporarily stores hazardous waste, but as the company grows, several new rooms or facilities will be needed to support the production process. Therefore, changes in waste production necessitate the redesign of the hazardous waste storage facility. The data collection method used primary data (field observations and interviews) and secondary data (Rintek Hazardous Waste Management and regulations applicable to hazardous waste management in Indonesia). Based on the findings of gaps and waste volume data, the number of containers was recalculated, and a space requirement analysis was carried out by grouping waste into compatible zones and ensuring physical separation. The selection of containers and packaging materials was adjusted to the waste's physical and chemical properties. The redesigned layout applies a separate block system based on a compatibility matrix so that incompatible waste is not stored side by side, with a safe distance of 60 cm in accordance with Minister of Environment and Forestry Regulation No. 6 of 2021.

Contribution to Sustainable Development Goals (SDGs):
SDG 3 – Good Health and Well-being
SDG 9 – Industry, Innovation, and Infrastructure
SDG 13: Climate Action

1. INTRODUCTION

1.1. Research Background

The industrial sector plays an important role in a country's economic growth, helping to create a more stable and sustainable economy[1]. In Indonesia, the industrial sector has made a significant contribution to economic growth. In recent years, according to [2, based on data from the Central Statistics Agency (BPS), the manufacturing industry has been the largest contributor to Gross Domestic Product (GDP). However, despite its role in economic growth, the industrial sector is also a major contributor to environmental pollution due to increased waste, whether in solid, liquid, or gaseous forms[3]. One type of waste that every industry must manage is Toxic and Hazardous Waste (B3).

Hazardous waste is waste generated by a business or activity that hashemical, physical, or biological characteristics that can pose a serious danger to human health and the environment if not handled properly [4]. Hazardous waste can not only damage the environment, but also disrupt human health [5]. Therefore, all parties that produce hazardous waste are required to manage it. According to Government Regulation No. 22 of 2021, hazardous waste management is an activity that includes reduction, storage,

collection, transportation, utilization, processing, and/or disposal [6]

This industry manufactures medical equipment. Its production generates both hazardous and non-hazardous waste. Hazardous waste is generated from the production process and facility maintenance. Some of the hazardous waste generated includes used lubricating oil, rejects, rags, and fluorescent lights. This hazardous waste has four characteristics: flammable solids, flammable liquids, infectious, and toxic.

1.2. Literature Review

The storage of hazardous waste must comply with compatibility rules, namely the grouping of waste based on similar characteristics to avoid mixing hazardous materials. Compliance with these rules is very important to prevent uncontrolled chemical reactions that can cause fires or other hazards. Details of the compatibility guidelines are in Appendix VI of the Minister of Environment and Forestry Regulation No. 6 of 2021.

LIMBAH B3	CAIRAN MUDAH TERBAKAR	PADATAN MUDAH TERBAKAR	REAKTIF	MUDAH MELEDAK	BERACUN	CAIRAN KOROSIF	INFEKSIUS	BERBAHAYA TERHADAP LINGKUNGAN
CAIRAN MUDAH TERBAKAR	C	C	C	X	X	C	C	T
PADATAN MUDAH TERBAKAR	C	C	C	C	X	T	C	T
REAKTIF	C	C	C	C	X	T	C	T
MUDAH MELEDAK	X	C	C	C	X	T	C	T
BERACUN	X	X	X	X	C	X	C	T
CAIRAN KOROSIF	C	T	T	T	X	C	C	T
INFEKSIUS	C	C	C	C	C	C	C	C
BERBAHAYA TERHADAP LINGKUNGAN	T	T	T	T	T	T	C	C

Fig 1. Compatibility Matrix of Hazardous Waste Characteristics (Source: Minister of Environment and Forestry Regulation No. 6 of 2021, Appendix VI)

Description :

- C = Compatible, meaning that one characteristic of Hazardous Waste can be grouped with the same characteristics of Hazardous Waste or with other characteristics of Hazardous Waste.
- X = Incompatible, meaning that one characteristic of Hazardous Waste cannot be grouped with other characteristics of Hazardous Waste.
- T = Limited, meaning that one characteristic of Hazardous Waste can be grouped with other characteristics of Hazardous Waste, but with a limited volume.

1.3. Research Objective

This study aims to evaluate the layout of hazardous waste placement at the Hazardous Waste Storage Site for Medical Device Manufacturing Industries with reference to Minister of Environment and Forestry Regulation No. 6 of 2021 concerning Procedures and Requirements for the Management of Hazardous and Toxic Waste (PERMEN LHK N0. 06 TAHUN 2021, 2021). This regulation includes more technical and detailed provisions on various aspects of hazardous waste management and serves to ensure that hazardous waste is managed properly and safely for the environment. This plan is expected to optimise the safety aspects of storage and ensure compliance with the environmental regulations applicable in Indonesia.

2. MATERIALS AND METHODS

2.1 Data Collection Method

Before conducting a study on the redesign of the hazardous waste storage facility layout, it is necessary to collect the latest, relevant data and information on the technical details, from the production of hazardous waste to its temporary storage. The following are the methods I used to collect data:

a. Field observation

The field observation method aims to obtain data on the actual condition of hazardous waste storage facilities, based on compliance with environmental standards forazardous waste management [7]. bservations were conducted systematically and documented, covering aspects such as the actual layout, compliance with hazard symbols and labels, physical characteristics of the waste, packaging specifications (type, estimated volume, and integrity), placement configuration, and availability of waste disposal site support facilities. In addition to visual inspections, technical measurements (dimensional measurements) were also carried out on the TPS area, the width of the transport access route, and the dimensions of the hazardous waste packaging.

b. Interview

To complete the observation data, interviews need to be conducted with parties involved in the management of hazardous waste in the Medical Device Manufacturing Industry. The parties in question are general division staff responsible for managing hazardous waste storage sites and K3/environmental staff. This method is applied to validate field findings and identify gaps (gap analysis) between technical document standards and operational realities in the field. During the interview, one of the required data is the method of implementing industrial hazardous waste management activities and the existing conditions in the company's environment, particularly the generation of hazardous waste [8].

c. Document study

Secondary data required in analyzing documents, including:

1. Detailed Technical Report on Hazardous Waste Management in the Medical Device Manufacturing Industry.
2. Government Regulation No. 21 of 2022 concerning the Implementation of Environmental Protection and Management.
3. Minister of Environment Regulation No. 6 of 2021 concerning Procedures and Requirements for the Management of Hazardous and Toxic Waste.
4. Ministry of Environment Regulation No. 14 of 2013 concerning Symbols and Labels for Hazardous and Toxic Waste.
5.

https://doi.org/10.29165/ajarcde.v9i3.863

2.2 Data Analysys Method

The data analysis method used is a combination of primary and secondary data. The required primary and secondary data are shown in Table 1.

Table 1. Type of Data Used

No	Primary Data	Secondary Data
1.	Field observation data	Detailed Technical Report on Hazardous Waste Management
2.	Interview report	Government Regulation No. 21 of 2022 concerning the Implementation of Environmental Protection and Management.
3.		Minister of Environment Regulation No. 6 of 2021 concerning Procedures and Requirements for the Management of Hazardous and Toxic Waste.
4.		Ministry of Environment Regulation No. 14 of 2013 concerning Symbols and Labels for Hazardous and Toxic Waste.

The output from processing these two types of data will be presented in the form of tables, new layout design images, and narrative explanations [9]. All hazardous waste is classified according to its respective characteristics. The data will be mapped according to the compatibility matrix in Table 2 of Appendix IV of the Minister of Environment and Forestry Regulation No. 6 of 2021, to identify pairs of waste characteristics that are Compatible or Incompatible. Next, compare the existing layout with the compatibility matrix and critically evaluate the arrangement of incompatible waste. Pay attention to other technical requirements, such as the distance between waste piles, road width, hazardous-waste capacity in each block, and pallet capacity.

Based on the findings of gaps and waste volume data, we recalculated the number of packages and analysed space requirements, including designing a new block layout that grouped waste into compatible zones and ensured safe physical separation. The final stage involved presenting the data in a new layout plan as a recommendation for the safe and compliant management of hazardous waste, in accordance with applicable regulations.

3. RESULT AND DISCUSSION

3.1. Identification of Toxic and Hazardous Waste

The Medical Device Manufacturing Industry produces waste, both hazardous and non-hazardous, in its production process. There are two ways to determine whether waste is hazardous: laboratory testing and identification using a government-compiled waste list, as is suspected of having hazardous waste characteristics [10]. The hazardous waste that has been analyzed comes from production and facility maintenance activities and will undergo an inventory process and be reported to the Health, Safety, and Environment Division. The waste is then temporarily stored at the Hazardous Waste Storage Site for a specified storage period of 90 days (3 months) or 180 days (6 months) in accordance with applicable technical regulations. The results of hazardous waste identification in the industry are shown in Table 2.

Table 2. Results Of Hazardous Waste Identification

No	Type of Waste	Source	Waste Code	Carac-teristic	Total Waste
1.	Used lubricating oil	Inject production, maintenance	B105d	Flamma-ble liquid	50
2.	Reject product	Inject production & Assy production	A336-1	Infectio us	372,5
3.	Fluorescent lamp	maintenance	B107d	Toxic	7
4.	Used majun	Production and maintenance	B101d	Flamma ble solid	40

The hazardous waste generation data presented in Table 2 is a summary of daily logbook records for the last 3 to 6 months of 2025. This data is used to determine the average monthly rate of hazardous waste generation. Based on its characteristics, used lubricating oil comes from preventive maintenance and periodic oil changes in the hydraulic system of injection engines. Meanwhile, reject product waste is defined as products that do not meet quality specifications (non-conforming quality), including syringes, spouts, and electromedical instruments. In the electronics category, fluorescent lamp waste is generated from replacing units that have reached the end of their service life or are physically damaged, so the generation rate tends to be fluctuating and incidental. Finally, used rags are porous solid waste generated from cleaning activities in the Injection and Assembling units, with a high level of contamination due to the absorption of lubricant residues and operational chemicals.

Every producer of hazardous waste must place hazardous waste in suitable containment to ensure safety during temporary storage until transport. The form and material of the packaging are selected based on their suitability for the type and characteristics of the hazardous waste to be packaged. The following principles are used when packaging hazardous waste:

a. Hazardous waste that is incompatible must not be stored together in the same container.
b. Packaging must be inspected by an officer to ensure there is no damage or leakage caused by corrosion or other factors. If it is in an unsuitable condition or leaking, it must be transferred to another packaging that meets the requirements.
c. Hazardous waste packaging must be marked/labeled in accordance with the characteristics and hazards listed in (Ministry of Environment Regulation No. 14 of 2013, 2013).
d. All stages of hazardous waste storage must be reported as part of the hazardous waste treatment process.
e. Packaging that has been filled with Hazardous Waste must be tightly sealed and only opened when adding or removing Hazardous Waste.

Table 3. Packaging of Hazardous Waste

No	Type of Waste	Waste Code	Packaging
1.	Used lubricating oil	B105d	Metal drum capacity 200 liter
2.	Reject product	A336-1	Fiber drum capacity 200 liter
3.	Fluorescent lamp	B107d	Cardboard
4.	Used majun	B101d	Fiber drum capacity 200 liter

Based on the type of hazardous waste to be packaged, packaging and packaging materials are selected to match the physical and chemical properties of each waste. The packaging used must be in safe condition, rust-free, and show no signs of leakage [11]. Each package must have a label and symbol for Hazardous Waste affixed in a place that is easily readable or visible, in accordance with the characteristics of each type of Hazardous Waste to be packaged [12]. Used lubricating oil is a flammable liquid waste. It is packaged in metal drums because they can withstand heat and have a much higher melting point than plastic drums. Reject product waste is infectious solid waste, as the cellulose material in fibre drums allows for direct incineration without separating the contents from the container, thereby avoiding the risk of injury from sharp objects.

3.2 Calculation of Packaging and Pallet Quantity

In designing the new layout for the Temporary Storage Site for Hazardous Waste, it is necessary to calculate the number of hazardous waste containers required based on the waste generation data listed in the hazardous waste logbook [13]. Estimates of hazardous waste packaging requirements must account for the planned storage period to avoid either too little or too much waste accumulation [14]. In addition, when projecting packaging requirements, the maximum amount of hazardous waste must be considered to estimate the appropriate packaging capacity to contain it [15]. Click or tap here to enter text. The following is the formula for calculating the required amount of hazardous waste packaging:

$$\text{Total Packaging} = \frac{Total\ waste\ x\ Storage\ time}{Packaging\ capacity - 10\%}$$

3.1.1. Calculation of used lubricating oil packaging

Hazardous and Toxic Waste (B3) in the form of used lubricating oil (waste code: B105d) originating from Injection Production and Maintenance will be stored for a period of 6 months (180 days). With an average generation rate of 50 litres/month, the total accumulation of waste during the storage period is estimated at 300 litres. Storage will be carried out using 200-litre metal drums (60 cm in diameter, 80 cm in height). The packaging requirements analysis is presented as follows:

$$\text{Packaging} = \frac{Total\ waste\ x\ Storage\ time}{Packaging\ capacity - 10\%}$$
$$= \frac{50 \frac{liter}{month} x\ 6\ month}{200\ liter - 10\%}$$
$$= \frac{300\ liter}{180\ liter}$$
$$= 1{,}67 \text{ drum, rounded to 2 metal drums}$$

3.1.2. Calculation of rejected product packaging

Reject Product Waste (waste code: A336-1) is identified as the most significant contributor to B3 waste volume in this industry, originating from the Inject and Assembly production units. Based on an average generation rate of 372.5 kg/month, the total accumulation of waste during the 3-month (90-day) storage period is projected to reach 1,118 kg. Storage is carried out using 50-liter fiber drums (58 cm in diameter, 88 cm in height). With an estimated density of reject product waste of 0.175 kg/litre, the effective storage capacity for each 200-litre fibre drum unit is calculated to be 35 kg. The analysis of the number of containers required is described as follows:

$$\text{Packaging} = \frac{Total\ waste\ x\ Storage\ time}{Packaging\ capacity - 10\%}$$
$$= \frac{372{,}5 \frac{kg}{month} x\ 3\ month}{35\ kg - 10\%}$$
$$= \frac{1118\ kg}{31{,}5\ kg}$$
$$= 35{,}5 \text{ drum, rounded to 36 fiber drums}$$

3.1.3. Calculation of used fluorescent lamp

Electronic waste in the category of fluorescent lamps (TL lamps) with waste code B107d, originating from facility maintenance activities, is planned to have a storage period of 3 months. Based on an average generation rate of 7 kg/month, the estimated total waste accumulation during the storage period is 21 kg. Packaging is carried out using cardboard boxes with a maximum load capacity of 10 kg and dimensions of 80 cm x 50 cm x 40 cm. The analysis of the number of packages required is determined as follows:

$$\text{Packaging} = \frac{Total\ waste\ x\ Storage\ time}{Packaging\ capacity - 10\%}$$
$$= \frac{7 \frac{kg}{month} x\ 3\ month}{10\ kg - 10\%}$$
$$= \frac{21\ kg}{9\ kg}$$
$$= 2{,}3 \text{ cardboard, rounded to 3 cardboard}$$

3.1.4. Calculation of used majun

Hazardous waste in the form of contaminated rags (waste code: B101d) originating from the Inject Production, Assembly, and Maintenance units is planned to be stored for a period of 3 months (90 days). Based on an average generation rate of 40 kg/month, the total accumulation of waste during this period is projected to reach 120 kg. The waste will be stored in 200-litre fibre drums measuring 58 cm in diameter and 88 cm in height. With an estimated density of 0.3 kg/L, the effective storage capacity per container is 60 kg. The analysis of the number of containers required is as follows:

$$\text{Packaging} = \frac{Total\ waste\ x\ Storage\ time}{Packaging\ capacity - 10\%}$$
$$= \frac{40 \frac{kg}{month} x\ 3\ month}{25\ kg - 10\%}$$
$$= \frac{120\ kg}{22{,}5\ kg}$$
$$= 5{,}3 \text{ drum, rounded to 6 fiber drums}$$

After determining the total amount of hazardous waste and the number of containers required, pallets are essential as a base layer to prevent container leakage. By considering the characteristics of hazardous waste produced by the industry, the use of pallets can be minimized.

https://doi.org/10.29165/ajarcde.v9i3.863

Table 4. Pallet Requirements

No	Carac-theristic	Type of Waste	Total Packa ging	Surface area (m^2)	Dimension of pallet
1.	Flamma-ble liquid	Used lubricating oil	2	2,26	130x130x30
2.	Infectio-us	Reject product	36	38	120x100x15
3.	Toxic	Fluorescent lamp	3	0,4	120x100x15
4.	Flamma ble solid	Used majun	6	6,34	130x130x30

Based on the data in Table 4, the number of pallets is determined by the effective storage capacity of the pallets in relation to the diameter of the packaging. The storage configuration uses a limited stacking system (maximum 2 levels), in which pallets play a vital role as interfaces to prevent direct contact with the floor and to monitor the integrity of the packaging for leaks. Furthermore, the spatial design applies block segregation based on waste characteristics with a safe distance of 60 cm between blocks. This distance has been adjusted to comply with the provisions of the Minister of Environment and Forestry Regulation No. 6 of 2021, to ensure smooth material-handling operations and prevent harmful interactions between different types of waste.

3.3 Redesign plan for hazardous waste disposal site

An industry that produces hazardous waste must store it if it cannot immediately process a certain amount. The purpose of storing hazardous waste is to prevent its release into the environment, thereby minimising potential danger to humans and the environment[16]. According to [17] In his research, hazardous waste storage facilities must meet several general requirements, such as being located in areas that are not prone to flooding or natural disasters, having an adequate ventilation system, being equipped with hazardous waste symbols in accordance with the characteristics of the waste stored, and having a waterproof floor that slopes 1% towards the spill containment basin. One aspect of storage that was the main focus of this study was that waste placement must comply with compatibility rules. However, during observations, hazardous waste with incompatible characteristics was found stored side by side without a safe distance between them. This could cause dangerous chemical reactions and hinder the manoeuvrability of transport equipment during the waste transfer and transportation. Based on a direct review of the B3 waste storage site at this industry, several field findings did not comply with regulations. A complete explanation can be seen in Table 5.

Table 5. Results of Hazardous Waste Storage Facility Review Analysis

No	Criteria	Conditions	Regulations
1.	Waste identification and classification	Waste with incompatible characteristics is stored together, such as flammable liquid waste and toxic waste placed side by side without a safe distance between them.	It is mandatory to identify and classify hazardous waste types based on their physical and chemical characteristics to prevent dangerous reactions between them.
2.	Waste reduction	Excessive accumulation of hazardous waste, which can hinder the management of hazardous waste in accordance with applicable regulations.	- Implementing a better injection machine optimization system to prevent physical defects. - Using all sides of the fabric to the maximum before disposal. - Replacing lamp materials with LEDs that have a longer service life and are environmentally friendly.
3.	Ease of transportation / shipping	Improper waste disposal and lack of safety distance.	Create layout blocks based on their characteristics, maintaining a safe distance of 60 cm between blocks to facilitate the movement and transport of hazardous waste.
4.	Design and construction	The floor slope is still insufficient to drain liquid leaks into the spill containment basin.	Make the base floor slope down toward the spill containment basin with a maximum slope of 1%.
5.	Lighting system	No lighting system in the TPSL B3 building	The lighting system is tailored to the hazardous waste storage facility's design.

Based on this direct review, several aspects of hazardous waste management were found to remain out of compliance with

applicable regulations. Therefore, it is necessary to replan hazardous waste management to ensure more efficient and saferaste management [18]. The dimensions of the available hazardous waste storage area are 600 x 485 x 300 cm. The following are images of the existing conditions and the redesign plan for the hazardous waste storage area:

Fig 2. Initial condition of the hazardous waste storage facility

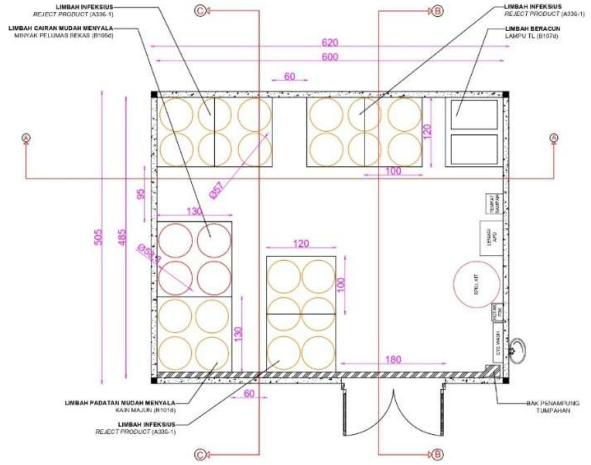

Fig 3. Redesign plan of the hazardous waste storage facility

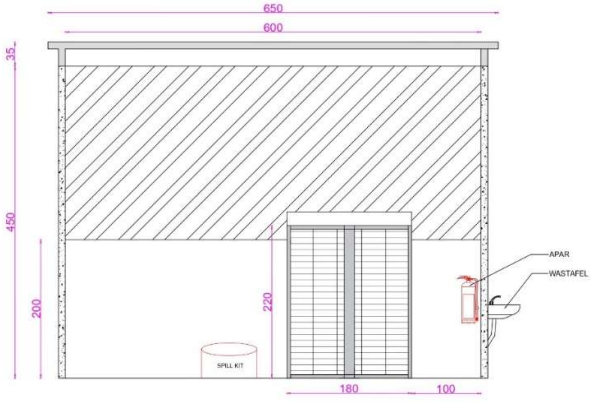

Fig 4. Front view of the hazardous waste storage facility

Fig 5. Section A of the hazardous waste storage facility

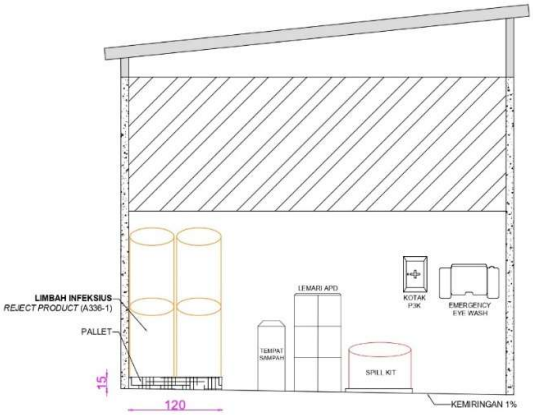

Fig 6. Section B of the hazardous waste storage facility

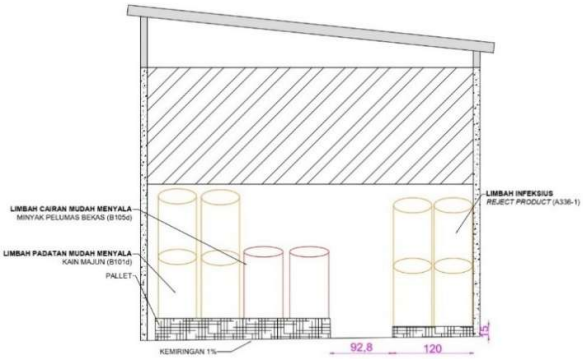

Fig 7. Section C of the hazardous waste storage facility

Overall, the redesign of the hazardous waste storage area layout has two significant positive impacts. First, in terms of safety, implementing a separate block system (segregation) that complies with compatibility rules has proven effective in reducing the risk of hazardous waste contamination. Second, from an operational perspective, providing safe distances between blocks in accordance with the standards set out in the Minister of Environment and Forestry Regulation No. 6 of 2021 creates adequate access routes. This not only ensures compliance with regulations but also facilitates the manoeuvring of transport equipment, making the waste management process smoother, safer, and more efficient.

https://doi.org/10.29165/ajarcde.v9i3.863

4. CONCLUSION

Based on the redesign of the Hazardous Waste Storage Facility layout in the Medical Device Manufacturing Industry, it can be concluded that the storage process for Hazardous Waste has become safer, more structured, and compliant with applicable regulations. There are four types of Hazardous Waste produced, namely used lubricating oil (B105d), which is a flammable liquid; Reject Product (A336-1) in the form of syringes and electromedical devices with infectious properties, electronic waste from fluorescent lamps (B107d) with toxic characteristics, and used rags (B101d) with flammable solid properties. The largest amount of waste comes from reject products, amounting to 372.5 kg/month. The packaging and pallet requirements in Table 4 can accommodate the total generation over a storage period of 3 to 6 months. The redesigned layout implements a separate-block system based on a compatibility matrix (Figure 1), so that incompatible waste (such as flammable and infectious waste) is no longer stored side by side. Each storage block has a safety distance of 60 cm in accordance with Minister of Environment and Forestry Regulation No. 6 of 2021, which has a dual impact: mitigating the risk of cross-reactions between hazardous wastes and increasing operational efficiency by providing adequate transportation access.

REFERENCE

[1] D. Sagita Fitri *et al.*, "Pengaruh Pengembangan Sektor Industri Terhadap Pertumbuhan Ekonomi Di Indonesia," vol. 2, no. 1, pp. 204–215, 2025, doi: 10.61722/jrme.v2i1.3432.

[2] H. A. Prabowo R, "Kontribusi Industri Terhadap Pertumbuhan Ekonomi Nasional Industrial Contribution To National Economic Growth," *Variable Research Journal* , vol. 02, no. 3032–4084, pp. 212–217, 2025.

[3] Y. Bersih, B. Afra, H. Haifa1, A. Yogi, and O. U. Kamal3, "Tantangan dan Solusi Pengelolaan Limbah Industri: Upaya Menuju Lingkungan," *Jurnal Ilmiah Wahana Pendidikan*, vol. 10, no. 23, pp. 1133–1139, 2024.

[4] V. Alfianti, S. Rismawati, and N. Latifah, "Tinjauan Sistem Pengolahan Limbah B3 Pada Sektor Kesehatan Dan Industri," 2025.

[5] A. Febrianti, K. N. Mufidah, U. Islam, N. Sayyid, and A. Rahmatullah, "Analisis Dampak Pencemaran Limbah B3 Terhadap Perairan serta Pengelolaannya," *Jurnal Ilmu Sosial dan Humaniora*, vol. 1, no. 2, pp. 539–549, 2025, doi: 10.63822/2kn2re75.

[6] PP 22 TAHUN 2021, "Peraturan Pemerintah Republik Indonesia No. 22 Tahun 2021 Tentang Penyelenggaraan Perlindungan Dan Pengelolaan Lingkungan Hidup," 2021.

[7] M. S. Y. Argia and M. F. Fadhil, "Evaluasi Dan Rekomendasi Pengelolaan Limbah Bahan Berbahaya," *Jurnal serambi Engineering*, vol. 10, no. 1, pp. 12838–12845, Jan. 2025.

[8] E. Yafi Bachtiar and H. Cahyonugroho, "Redesain Tempat Penyimpanan Sementara Limbah B3 Pada Pabrik Pembekuan Ikan PT. XYZ Kabupaten Surabaya," *Jurnal Serambi Engineering*, vol. X, no. 3, pp. 9390–9397, Jun. 2025.

[9] Y. S. R. H. , G. H. Afifazari Elfia N.R, "Redesain Tempat Penyimpanan Sementara (TPS) Limbah Bahan Berbahaya dan Beracun (B3) pada Perusahaan Jasa Pengangkutan Sesuai dengan Peraturan dan Limbah yang Dihasilkan," *Jurnal Praktik Keinsinyuran*, vol. 1, no. 2, pp. 365–377, 2024.

[10] E. W. Fajriyah Siti Amalia, "Evaluasi Pengolahan Limbah Bahan berbahaya dan beracun (B3) di PT X," *Jurnal serambi Engineering*, vol. 5, no. 1, pp. 711–719, 2020.

[11] R. Wardhani Eka, "Identifikasi Timbulan dan Analisis Pengelolaan Limbah B3 di Pabrik Kertas PT X," *Serambi Engineering*, vol. 5, no. 3, pp. 1251–1261, 2020.

[12] E. Herliana, A. Gunawan, and N. L. Latifah, "Pengelolaan Limbah Bahan Berbahaya Dan Beracun (B3) Dari Laboratorium Pt Max Chem Indonesia," 2024.

[13] A. B. Yudhistira, M. Abdus, and S. Jawwad, "Redesign Planning of B3 Waste Temporary Storage Site (TPS) of PT X Located in Pasuruan Industrial Estate Rembang (PIER)," 2025. [Online]. Available: http://envirous.upnjatim.ac.id/

[14] S. A. W. Pramestie I.S.D, "Evaluasi Pengelolaan Limbah Bahan Berbahaya," *Jurnal Teknik ITS*, vol. 12, no. 2, pp. 95–102, 2023.

[15] S. S. Desnita and N. Halomoan, "Proyeksi Kebutuhan Kemasan Limbah B3 di PT. X," 2024.

[16] V. W. R. Luthfi, L. Zohrah, and V. Ulya Bunga, "Kajian PengelolaanTempat PenyimpananLimbahBahan Berbahaya dan Beracun di Perusahaan Jasa Pengumpulan dan Pengangkutan," *Blend Sains Jurnal Teknik*, vol. 4, no. 2, pp. 288–297, 2024, doi: 10.56211/blendsains.v4i2.1292.

[17] F. P. Putra, "Pengelolaan Limbah Bahan Berbahaya Dan Beracun (B3) Di Tempat Penyimpanan Sementara PT. X," *Jurnal Multidisiplin Ilmu Akademik*, vol. 2, no. 5, pp. 613–619, Oct. 2025.

[18] A. Wahyu, A. Miyana, M. Nilam Kusuma, M. T. Lingkungan, T. Adhi, and T. Surabaya, "Studi Redesain Tempat Penyimpanan Sementara (TPS) Limbah B3 sesuai dengan Limbah yang Dihasilkan dan Peraturan Terbaru di PT X," *Environmental Engineering Journal ITATS ENVITATS*, vol. 4, no. 1, pp. 38–47, 2024.