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Research Paper

Toxic and Hazardous (B3) Solid Waste Management at Abdul Moeloek General Hospital: An Implementation Assessment in 2022 and Recommendations

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Abstract
Making sure that the health and environment are taken care of, solid B3 Waste produced by hospitals has to be treated according to existing regulations. As an A-class hospital in Bandar Lampung, AM General Hospital commit to conducting good practices for its solid B3 waste management. This study aims to analyze the current implementation of solid B3 waste management, the compliance of AM General Hospital's B3 waste management Standard Operation Procedure (SOP) with current regulations, and recommend improvement strategies for solid B3 waste management in AM General Hospital. For eight consecutive days in August 2022, solid B3 waste samples were collected and analyzed. The average solid B3 waste produced by AM General Hospital was 285 kg/day for infectious waste and 6.3 kg/day for sharp waste. Inpatient installation contributed the majority of solid B3 waste there. Due to the observation sheet that was created according to the regulations, 65% of AM General Hospital's SOP involving sorting; storage; collection; transportation; and disposal has already complied with the regulations. Several shortcomings were found such as the absence of an official solid B3 waste handling report; the absence of proper labeling in the B3 waste containers; and the use of black plastic bags. Analytical Hierarchy Process (AHP) data analysis technique was deployed, resulting in a technology application and waste minimization as improvement recommendations.

Keywords
Solid B3 Waste Management, Hospital, Assessment, AHP, SOP

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1. INTRODUCTION

15% of the total amount of waste produced by healthcare activities is considered hazardous material that may be infectious, toxic, or radioactive (World Health Organization, Health-care Waste). General Hospital is a vital facility in supporting citizens' health care which produces solid hazardous and toxic waste or so-called solid B3 waste that could cause serious infection and poses a potential threat to the surrounding environment, to the public in general, and the person handling it (Freeman, 1989). Solid B3 waste generated from hospitals includes hypodermic needles, blades, scalpels, gloves, surgical cotton, bandages, discarded medicine, clothes, body fluids, human tissues and organs, chemicals, etc (Radha et al., 2009).

Good practices of B3 waste management could be implemented with the support of policies such as regulatory documents, SOPs, and comprehensive work instruction based on regulations (Hutajulu et al., 2022). Poor management of solid medical waste in hospitals can endanger the health and the environment. This can cause all hospital workers, medical waste handlers, and the public to be exposed to infection, toxic effects, and injury (Wilhemina et al., 2022).

Based on the potential hazards of medical waste, the types of waste can be classified into Infectious, Non-infectious, Body Tissue, Cytotoxic, and Pharmaceutical Waste. Infectious waste may contain various types of pathogenic microorganisms that can enter the human body through several ways such as punctures, cuts or skin wounds, mucous membranes, respiration, or ingestion. Sharp objects not only can cause scratches or puncture wounds but can also infect wounds if the object is contaminated with pathogens. Due to these risks (injury and disease transmission), sharp objects are classified as highly dangerous waste (Alam et al., 2019).

Abdul Moeloek General Hospital (AM Hospital) is a crucial A-class hospital in Bandar Lampung. The latest study in 2019 concluded that AM Hospital's solid B3 waste management has not met the regulation of the Indonesian Ministry of Health Regulation 1204 2004 yet (Tarigan, 2019). Awareness of solid B3 waste management's necessity was low. Moreover, combustion could not be performed because the incinerator device did not work well. Therefore, this research is conducted to analyze the existing condition of solid B3 waste management at AH Hospital, to assess the compliance of AM General Hospital's SOP with existing regulations, and to recommend a strategic action plan to improve solid B3 waste management further.

According to the Indonesian Ministry of Health Regulation No. 7/2019, solid B3 waste management is a series of activities that include sorting, collection, transportation, storage, management, and disposal of medical waste. This article also highlights the important elements of medical waste management in hospitals, which include waste minimization, labeling and packaging, transportation, storage, management, and disposal.

A validity test is used to measure the validity of a questionnaire. A questionnaire is said to be valid if the questions on the questionnaire are able to reveal something that will be measured by the questionnaire. One of the most commonly used formulas is Pearson's correlation coefficient formula. The significance test from n data is done by comparing the value of the reference and calculated Pearson coefficient correlation (r) using the following Equation 1:

$$r = \frac{\sum xy - \frac{\sum x \sum y}{n}}{(\sum x^2 - \frac{(\sum x)^2}{n})(\sum y^2 - \frac{(\sum y)^2}{n})} \quad (1)$$

Cronbach Alpha (α) is one of the testing methods for reliability. One variable is said to be reliable when its value is more than 0.6. The value could be calculated using the following Equation 2:

$$r_x = \left(\frac{n}{n-1}\right)\left(1 - \frac{\sum \sigma t^2}{\sigma t^2}\right) \quad (2)$$

With r_x standing for reliability value, n is the number of questions, and σ is variance.

General Hospital Bandar Lampung General Hospital as the research material on August 2022 for eight consecutive days.

The primary data was collected through observations, interviews, questionnaires, and documentation. The observation was conducted to obtain a visual representation of the waste management process, while interviews and questionnaires were conducted to obtain the opinions and experiences of hospital staff. The secondary data was obtained from AM General Hospital Bandar Lampung documentation and literature studies. The documentation review focused on the waste management policy and procedures, while literature studies were conducted to obtain information on best practices and regulations on solid medical waste management.

2. EXPERIMENTAL SECTION

This study utilized a mixed-methods approach to investigate solid medical waste management in hospitals. This study was conducted by following the flowchart presented in Figure 1. The literature study was conducted to learn about current regulations and some legal documents of AM General Hospital. Instrument testing in this study was performed on each statement item, which consisted of 7 statements from 30 respondents. The validity test in this study used the SPSS application.

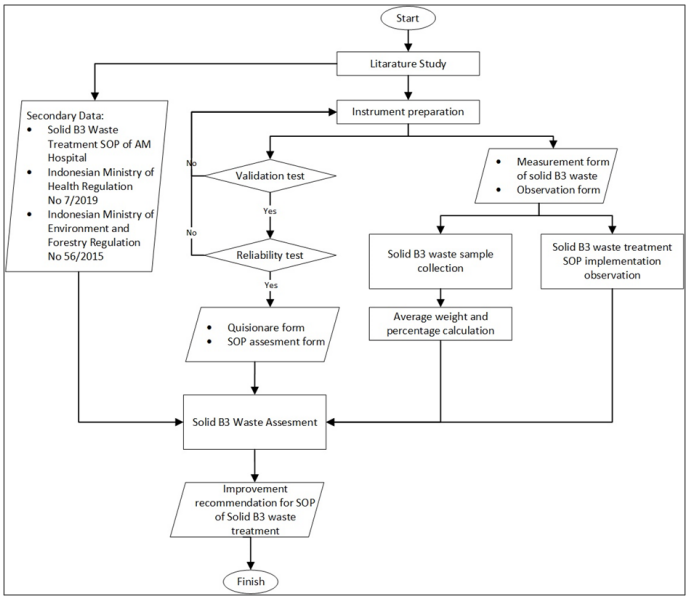

Figure 1. Research Flow Chart

The significance value of all 7 statements was more than 0.05 which means all of the statements were valid. The reliability test was done using Cronbach Alpha (Equation 2) resulting reliability coefficient equal to 0.915 which means that all of the questions were reliable. Solid B3 waste sample was collected on August 2022 for eight consecutive days.

3. RESULTS AND DISCUSSION

3.1 Current Condition of Solid B3 Waste Management at AM General Hospital

Solid B3 Waste management at AM General Hospital is carried out under the Environmental Health unit. The main responsibility of this unit is to develop and implement hospital sanitation programs based on the decision of the AM General Hospital Director Number 180/01.H/VII.02/7.2/VII/2020 regarding the establishment of the hospital's environmental health installation. The organizational structure of the Environmental Health unit is shown in Figure 2.

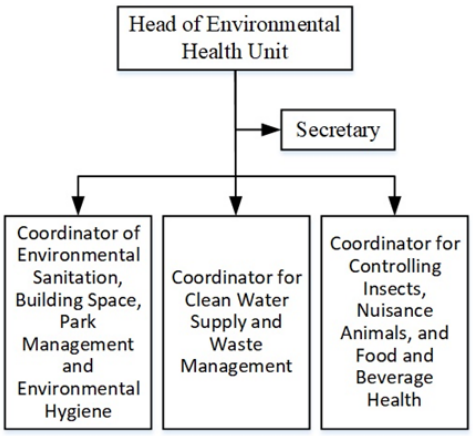

Figure 2. The Organizational Structure of the Environmental Health Unit

The schematic workflow of Solid B3 Waste management is shown in Figure 3. Solid B3 Waste management activities have been carried out at AM General Hospital by separating recyclable medical waste such as infusion bottles and outworn hemodialysis fluid bags for washing and disinfection processes at the 3R waste management facility. The procedure follows the Ministry of Environment and Forestry Regulation No. P.56 of 2015.

Sorting is done by separating medical and non-medical waste. Solid B3 wastes are divided into infectious waste and sharp medical waste. Sharp waste is collected using safety boxes, while infectious waste is collected using yellow-colored plastic bags. Solid B3 Waste is collected every morning and evening or as needed by the cleaning service staff. The process of collecting and transferring Solid B3 Waste is done by carrying the waste container on a trolley to the LB3 waste management facility. Based on observations, the LB3 facility is able to accommodate waste produced for temporary storage before it is transported. Transportation and disposal of Solid B3 Waste at AM General Hospital in Bandar Lampung are carried out by a third party, PT. Universal Eco Pacific.

The cooperation between AM General Hospital in Bandar Lampung and the waste transport/disposal service provider is based on a work contract. Based on observations and respondent interviews, the waste transporters from PT. Universal Eco Pacific comes with a special Solid B3 Waste vehicle to collect Solid B3 Waste three times a week: on Tuesdays, Thursdays, and Saturdays, from 9 am to 12 pm Western Indonesia Time. The vehicle used is a suitable and enclosed box truck with B3 symbols and the transporter company's identity on the vehicle. The staff from PT. Universal Eco Pacific and AM General Hospital in Bandar Lampung use personal protective equipment such as masks, gloves, long clothes, and boots.

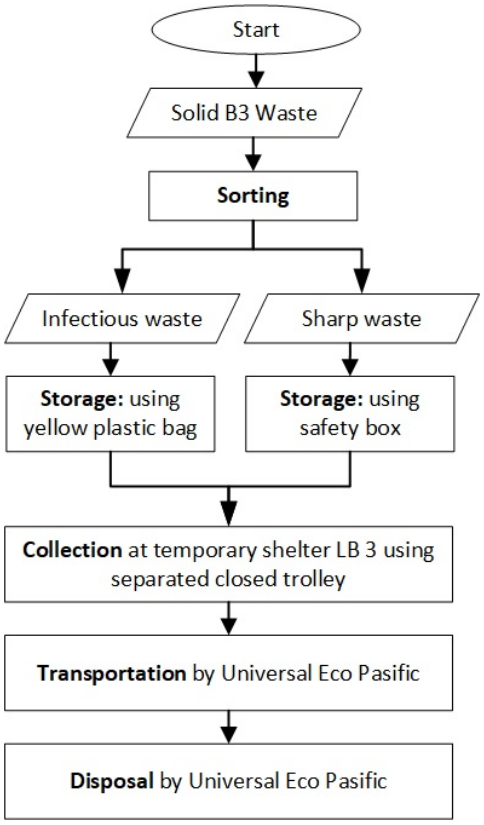

Figure 3. Schematic Diagram of Solid B3 Waste Management at AM General Hospital

3.2 Solid B3 Waste Amount, Composition, and Sources

Based on the data in Table 1, solid B3 waste at AM General Hospital is divided into two categories, they are infectious waste and sharp objects waste originating from medical activities. The dominant compositions of infectious medical waste generated in public hospitals was infectious waste, sharps, and pathological wastes (Lemma et al., 2022). Most of the solid B3 waste consists of medical equipment and materials as well as Personal Protective Equipment (PPE) that are exposed to chemicals or residue from patient care.

Table 1. Solid B3 Waste Categories and its Items

Solid B3 Waste Category	Solid B3 Waste Item
Sharp objects waste	Syringes, Vial bottles, IV needles
Infectious waste	Masks, IV bags, Blood bags, Gauze, Gloves, Headcovers, and Aprons

Source: Observation Results, 2022

Just like in another study, the quantity of Solid B3 waste before disposal was weighted (Tsakona et al., 2007). The

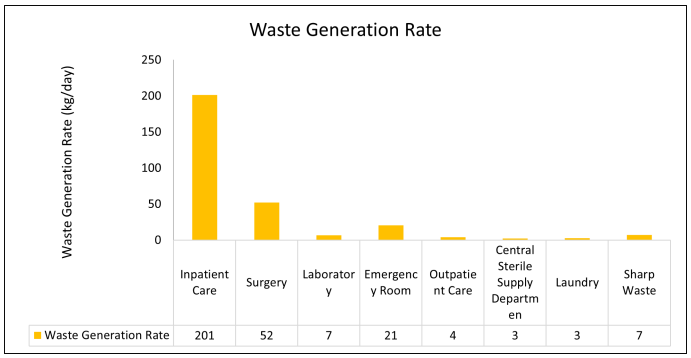

Figure 4. The Daily Average Weight of Infectious Waste from Each Source at AM General Hospital

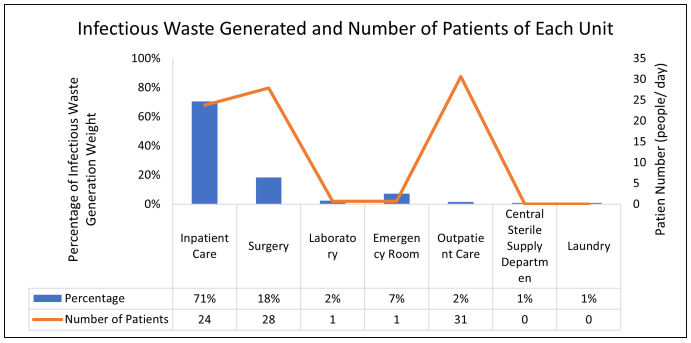

Figure 5. The Waste Generation Percentage Overlaid by Number of Patience from Each Source at AM General Hospital

measurement of solid B3 waste was conducted on the basis of the Indonesian National Standard called SNI 19-3694-1994 to obtain the average daily weight of each source of infectious and sharp objects waste at AM General Hospital Bandar Lampung, as shown in Figure 4. The infectious waste is grouped by the management room, including inpatient, outpatient, surgery, emergency installation, and hospital support activities such as laboratory installations, Central Sterile Supply Department (CSSD) installations, and laundry installations. The total average weight of infectious waste at AM General Hospital is 285 kg/day, where the largest source of medical waste is from the inpatient unit at 201 kg/day (70%), while the smallest source is from CSSD and laundry installations by 3 kg/day (2%). This is supported by the number of patient data served by each management unit as shown in Figure 5.

Several factors affect the amount of medical waste generated by each unit such as the level of medical service, the average daily number of visits, the type of disease, the number of medical staff, and the number of inpatients in the hospital (Wisaksono, 2001). This is also confirmed by Askarian et al. (2004) who states that the factors affecting the generation of solid B3 waste in hospitals include occupancy rates, types of medical treatment, and the number of patient visits. The inpatient unit is the largest source of medical waste generators because it has the second largest number of patients, 24 patients per day on average. They also provide more medical treatments than other units. It is also confirmed by Osman et al. (2023) that in terms of waste quantities the unit with the highest generation waste was the inpatients. The outpatient unit has a large number of patients but generates less waste because the unit only performs diagnostic examinations. The CSSD unit is responsible for sterilizing medical equipment in AM General Hospital Bandar Lampung. Meanwhile, the waste generated by the laundry unit consists of personal protective equipment used in laundry activities. As for the laboratory, it rarely receives patients/ samples, so the medical waste it generates is also minimal.

3.3 The Compliance Level of Solid B3 Waste Management at AM General Hospital

The analysis of the implementation of solid B3 waste management at AM General Hospital was done on the basis of Minister of Health Regulation Number 7 of 2019 and the requirements of Minister of Environment and Forestry Regulation Number: P.56/Menlhk-Setjen/2015. There are 5 management categories with 38 indicators. Compliance level assessment of solid B3 waste management at AM General Hospital according to the total score in each category of management is presented in Figure 6.

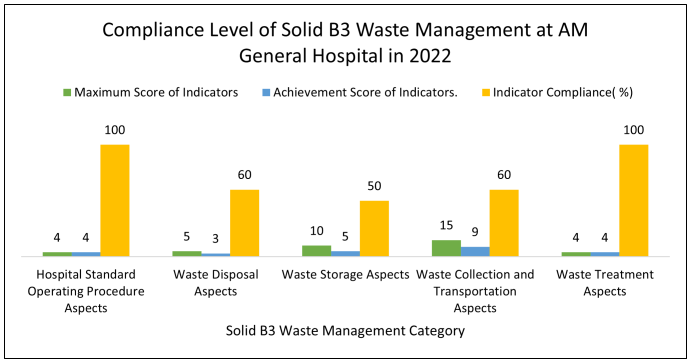

Figure 6. Compliance Level of AM General Hospital for Each Management Category

In Figure 6, the compliance level of the SOP aspect and processing aspect is 100% indicating that AM General Hospital has implemented medical solid waste management according to current regulations. The Storage aspect has the lowest compliance indicator level (50%), it is categorized as moderately compliant. This is due to the non-compliance of medical waste management in 5 out of a total of 10 indicators: storage location; storage of solid B3 waste according to solid B3 waste groups; storage of solid B3 waste using containers according to the group and characteristics of the waste; bag's color selection according to the characteristics of solid B3 waste; and the provision of solid B3 waste symbols and labels

Table 2. Priority Weights of Aspects in Selecting Alternative Medical Waste Management

Aspect	Aspect's Weight	Alternative Weight of Management Attempt		
		Waste Minimization	Recycling	Technology Application
Policy	0.18	0.18	0.11	0.72
Environmental Health	0.71	0.37	0.36	0.27
Financial	0.10	0.71	0.08	0.21
Total Weight		0.37	0.28	0.35
Priority		1	3	2

Table 3. Improvement Recommendation of Solid B3 Waste Management

Alternative Waste Management Strategies	Recommendations
Waste Minimization	Using a digital thermometer can reduce hazardous waste if a mercury thermometer is damaged (Smale et al., 2021) Not using aerosol air fresheners and identify appropriate vials sizes to use, and implement dose rounding of biologic and cytotoxic agents to decrease medication waste (Afanasjeva and Gruenberg, 2019) Centralizing and monitoring the flow/distribution of chemicals/hazardous waste according to their characteristics and types (Aprilia, 2019) Ensuring the expiration dates of products and medicines when delivered by suppliers (Wardhani and Kamil, 2020) Avoiding the use of materials that contain hazardous and toxic substances (Smale et al., 2021)
Application of Technology	Conducting internal processing using an incinerator (Osman et al., 2023) Choosing an incinerator with good air pollution control
Recycling	Sorting medical waste that can be recycled

on each bag or container according to the characteristics of solid B3 waste.

A lack of coding and labeling system for the different categories of hospital waste affects the efficiency of collection and handling and the integrity of the final waste treatment processes (Adu et al., 2020). The Processing and Collection-Transportation aspects have compliance indicator values of 60% or moderately compliant, indicating non-compliance with the indicators in both aspects. In the Processing aspect, there were indications of non-compliance in waste containers that were not equipped with B3 labels and symbols and waste bags that were too full and could not be tied with one knot. Non-compliance was also found in the Collection-Transportation aspect, where solid B3 waste collection was not accompanied by a waste delivery note, the transport vehicle had a different license plate number than the document stated, and there was no special route for solid B3 waste collection. A special route is needed to provide safety for people and environment while transporting medical waste to disposal (Agrawal et al., 2021). Overall, the level of compliance with solid B3 waste management implementation at AM General Hospital Bandar Lampung with existing regulations of all aspects is 65%.

3.4 Strategic Plan to Improve the Quality of Medical Solid Waste Management at AM General Hospital

The Analytical Hierarchy Process (AHP) method was chosen as a method to determine priorities in selecting alternative medical solid B3 waste management at AM General Hospital. The aspects measured for determining priorities are Policy, Environmental Health, and Financial aspects. The selection of Medical Solid Waste Management alternatives is divided into three categories: Waste Minimization, Recycling, and Technology Application. Based on the results of AHP calculations, weights, and priorities are obtained for each aspect in determining alternative medical solid waste management at AM General Hospital Bandar Lampung (Table 2).

The table above shows that the Environmental Health aspect has the highest weight of 0.71 compared to the Policy and Financial aspects in determining the selection of alternatives for improving the management of solid B3 medical waste. To measure the priority of alternative medical waste management options, paired comparisons were made between the alternatives and the aspects of Policy, Environmental Health, and Financial, resulting in a total weight for each alternative. The total weight value determines the

priority for selecting alternative efforts to manage hazardous waste at AM General Hospital, where the first priority is waste minimization with a weight of 0.37. The second priority is the technology application alternative with a weight of 0.35, and the third priority is the recycling alternative with a weight of 0.28. The efforts to improve the management of solid B3 waste based on the priority of alternative waste management options can be seen in the following Table 3.

4. CONCLUSIONS

The source of solid B3 waste at AM General Hospital comes from various service units, and the characteristics of the generated solid B3 waste are infectious waste and sharp object waste. The generation rate of infectious waste is 285 kg/day and the generation rate of sharp object waste is 6.3 kg/day. The level of compliance with the standard operating procedure (SOP) at AM General Hospital is 80%. The level of compliance of SOP with the applicable regulations is 80%. Meanwhile, the level of compliance with the applicable regulations is 65%. Based on the alternative calculation of solid medical waste management at AM General Hospital Bandar Lampung using the AHP method, the recommended alternative is waste minimization and technology application.

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REFERENCES

Adu, R. O., S. F. Gyasi, D. K. Essumang, and K. B. Otabil (2020). Medical Waste-sorting and Management Practices in Five Hospitals in Ghana. *Journal of Environmental and Public Health*, **12**; 1–14

Afanasjeva, J. and K. Gruenberg (2019). Pharmacists as Environmental Stewards: Strategies for Minimizing and Managing Drug Waste. *Sustainable Chemistry and Pharmacy*, **13**; 100164

Agrawal, P., G. Kaur, and S. S. Kolekar (2021). Investigation on Biomedical Waste Management of Hospitals Using Cohort Intelligence Algorithm. *Soft Computing Letters*, **3**; 100008

Alam, I., G. Alam, S. Ayub, and A. Siddiqui (2019). Assessment of Bio-medical Waste Management in Different Hospitals in Aligarh City. *Advances in Waste Management: Select Proceedings of Recycle 2016*, **502**; 501–510

Aprilia, B. S. (2019). *Efforts to Minimize and Manage B3 Solid Waste (Hazardous and Toxic Materials) at RSU Haji Surabaya*. Undergraduate Theses of Environmental Engineering UIN Sunan Ampel (in Indonesia)

Askarian, M., M. Vakili, and G. Kabir (2004). Hospital Waste Management Status in University Hospitals of the Fars Province, Iran. *International Journal of Environmental Health Research*, **14**(4); 295–305

Freeman, H. M. (1989). *Standard Handbook of Hazardous Waste Treatment and Disposal*. New York, NY (US); McGraw-Hill Book Co.

Hutajulu, S. M., I. Marsaulina, F. A. Siregar, and S. M. Indirawati (2022). Solid Medical Waste Management Strategy in Hospitals, Indonesia. *The Open Public Health Journal*, **15**(1); 1–7

Lemma, H., L. Asefa, T. Gemeda, and D. Dhengesu (2022). Infectious Medical Waste Management During the COVID-19 Pandemic in Public Hospitals of West Guji zone, Southern Ethiopia. *Clinical Epidemiology and Global Health*, **15**; 101037

Osman, A. M., Z. Ukundimana, F. B. Wamyil, A. A. Yusuf, and K. Telesphore (2023). Quantification and Characterization of Solid Waste Generated within Mulago National Referral Hospital, Uganda, East Africa. *Case Studies in Chemical and Environmental Engineering*; 100334

Radha, K., K. Kalaivani, and R. Lavanya (2009). A Case Study of Biomedical Waste Management in Hospitals. *Global Journal of Health Science*, **1**(1); 82–88

Smale, E. M., T. C. Egberts, E. R. Heerdink, B. J. van den Bemt, and C. L. Bekker (2021). Waste-minimising Measures to Achieve Sustainable Supply and Use of Medication. *Sustainable Chemistry and Pharmacy*, **20**; 100400

Tarigan, A. (2019). *Evaluation of Medical Solid Waste Management System at RSUD Abdul Moeloek Bandar Lampung in 2018*. Esa Unggul Undergraduate Theses of Public Health, Indonesia (in Indonesia)

Tsakona, M., E. Anagnostopoulou, and E. Gidarakos (2007). Hospital Waste Management and Toxicity Evaluation: A Case Study. *Waste Management*, **27**(7); 912–920

Wardhani, E. and F. A. Kamil (2020). Pengelolaan Limbah B3 di Rumah Sakit Gigi dan Mulut Universitas Padjadjaran Kota Bandung. *Jurnal Serambi Engineering*, **5**(4); 1443–1451 (in Indonesia)

Wilhemina, A., P. Amedumey, and G. B. H. Raphael (2022). Solid Waste Management in Hospitals: A Comparative Assessment in some Selected Hospitals in Obuasi Municipality of Ghana. *Cleaner Waste Systems*, **3**; 100025

Wisaksono, S. (2001). Characteristics of Hospital Waste and Their Impact on Health and the Environment. *Cermin Dunia Kedokteran*, **130**; 58–61 (in indonesia)

