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An Analysis of Hazardous and Toxic Waste Management (Case Study: Faculty of Mathematics and Natural Sciences Laboratory, Sebelas Maret University)

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ABSTRACT. In college, in the activities of the Tri Dharma has a primary place means of that Laboratory. The use of the laboratory is used as a place to do lab work, research, and research. In the activities carried out in the laboratory will inevitably produce waste, especially in the laboratory at the Faculty of Mathematic and Natural Sciences has many toxic and harmful chemicals or so-called hazardous and toxic Waste in it. As a step in the handling of hazardous and toxic waste such a system needs good management to avoid the occurrence of an indication of dangerous obtained from the waste to the human environment. The purpose of this study is to identify hazardous and toxic waste contained in the laboratory at the Faculty of Mathematics and Natural Sciences, Sebelas Maret University and know the management systems are applied. The method used in this research is the analysis of qualitative studies of literature and interviews. The results of the analysis showed that the Management of hazardous and toxic Waste conducted by the laboratory at the Faculty of Mathematics and Natural Sciences, Sebelas Maret University directly, namely: reduction, storage, packing, collection. As for the management of hazardous and toxic waste stage of utilization, processing, and transportation in cooperation with third parties. Hazardous and Toxic waste that is produced by the laboratory at the Faculty of Mathematics and Natural Sciences, Sebelas Maret University produce waste corrosive, toxic waste, waste easy, and the waste is easily oxidized. Required storage space that is good for storing hazardous and toxic waste that is produced by laboratory at the Faculty of Mathematics and Natural Sciences, Sebelas Maret University. Also need to do the evaluation and improvement of the system of management of hazardous and toxic waste is applied.

Keywords: Laboratory, waste management, hazardous and toxic materials.

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1. Introduction

A laboratory is a place that serves to conduct experiments, scientific studies, measurements, and research. Laboratories usually deal with science such as physics, Chemical, and biology. Within a laboratory must have the facilities and infrastructure that can support experimenting. Conditions for good laboratories among them have a good arrangement and room condition and have complete equipment. Where a laboratory must have an air vent in order to have an air circulation process, have an order, there is an emergency telephone number (such as a fire extinguisher), have a safety device (such as first aid and fire extinguishers), and must have an evacuation line (Maulana et al., 2019). In addition, the Laboratory must also be neatly aligned to facilitate the search for tools or materials and hazardous and toxic materials placed separately.

A laboratory may be adequate when it has complete and good facilities (Ula et al., 2018). Laboratories are becoming an essential condition and element that is mandatory in colleges (Cahyaningrum, 2020). In colleges, standards for laboratories generally contain about the essential management of

laboratories and the required facilities. Therefore, labs useful for learning have three skill goals, namely cognitive, affective, and psychomotor. The Laboratory became one of the contributors to hazardous and toxic material waste. Because the Laboratory produces waste, some of them have harmful material content, such as heavy metal content (Afriza et al., 2020).

Hazardous and toxic material waste is one of the wastes with significant negative impact potential because concentrations and quantities can contaminate and harm the environment, human health, and the destruction of survival of living things (Hariyadi et al., 2020). According to the Indonesian State Government Regulations, 22/2021 article 1 paragraph 67, hazardous and toxic material waste is a substance, energy, and or another component that, due to the nature, concentration, and or quantity, whether directly or indirectly, may defile and or damage the living environment, and harm the living, health, and survival of human beings dan other living things. Waste Hazardous and Toxic Substances are residues or wastes containing harmful and toxic chemicals derived from heavy metals such as iron (Fe) (Bempa and Kunusa, 2020).

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Hazardous and toxic material waste has characteristics under Indonesian State Government Regulations No. 22 of 2021 paragraph 278: corrosive, toxic, explosive, easily ignitable, reactive, and infectious. Based on the nature and negative impact it causes, then the waste is mandatory for proper management. Hazardous and toxic material waste managed under Indonesian State Government Regulations No. 22 of 2021 Paragraph 275, it is explained if the management of hazardous and toxic substances waste includes the determination, reduction, storage, collection, transportation, utilization, processing, disposal, exemption, cross-border transfer, countermeasure decollation of the environment and or deterioration of the environment and recovery of environmental functions, emergency response systems, and financing. In managing such waste, any party cannot perform, whereby an agency or company is obliged to obtain a license and all management activities are closely monitored and according to the applicable procedures. When it is unable to conduct waste management of hazardous and toxic materials, the management shall submit to the party who has obtained the permission (Muntazarah et al., 2020).

Under Indonesian state Government Ordinance No. 22 of 2021, they divided hazardous and toxic material waste into two categories. Category 1 is waste that could impact rapidly, and examples often used in laboratories are NaOH and Acetic Acid. At the same time, category two waste is waste whose impact is slow and long-term, for example, CuSO_4 and NH_4OH . Since 2009, the Faculty of MIPA has established a waste management unit to manage waste generated from various laboratory activities. In 2015 they built IPAL with the help of cooperation from the Ministry of Public Works (DPU). Such constructed IPALs are not only for wastes derived from the Faculty of Mathematics and Natural Sciences, Sebelas Maret University alone but also for wastes derived from the Faculty of Medicine. Therefore, hazardous and toxic material waste generated by the Faculty of Mathematics and Natural Sciences, Sebelas Maret University laboratories should adequately manage and process to not pose a more significant potential hazard. Therefore, this study was conducted to determine the classification and characteristics of hazardous and toxic material waste found in the Faculty of Mathematics and Natural Sciences, Sebelas Maret University laboratories. In addition, this study was also conducted to find out the waste management system of hazardous and toxic materials in the Faculty of Mathematics and Natural Sciences, Sebelas Maret University laboratories.

2. Materials and Methods

2.1 Time and Location



Fig.1 Chemical Laboratory, Faculty of Mathematics and Natural Sciences, Sebelas Maret University



Fig.2 Pharmaceutical Laboratory, Faculty of Mathematics and Natural Sciences, Sebelas Maret University

Analysis research on waste management of hazardous and toxic materials was conducted on 5-14 November 2021. The study was initiated with preparations that took two days, then a data collection process through interviews for three days, and a data analysis process obtained for four days. Research site this hazardous and toxic material waste management at the Laboratory of the University's Faculty of Mathematics and Natural Sciences March Eleven located on Jl. Ir. Sutami No. 36 A, Jebres, Jebres District, Surakarta City, Central Java. This study focused on analyzing waste management of hazardous and toxic materials in the Laboratory of Chemical Department and Laboratory of Pharmaceutical at the Faculty Mathematics and Natural Sciences.

2.2 Collecting Data

From the literature study results, it can be studied and understood the characteristics, classification, and waste management processes of hazardous and toxic materials applied in the laboratory. The collected data consists of quantitative and qualitative data. Data collection is performed both primary and secondary. Primary data were obtained through interview activities, conducting a query, and field observation directly. Secondary data is obtained by collecting literature study data and laboratory data comprising tool and material lists, MSDS documents, Standard Operation Procedure (SOP), and cross-checking in chemical materials cabinets.

2.3 Analysis Data

Data analysis was conducted by describing the results of primary and secondary data obtained relating to the management of hazardous and toxic materials waste in laboratories including, the scale and composition of hazardous and toxic materials waste, the characteristics of hazardous and toxic materials waste, and the management of hazardous and toxic materials waste. Data analysis was also carried out by evaluating waste management activities of hazardous and toxic materials applied to laboratories by attaching them to already studied literature studies.

3. Results and Discussion

3.1 Identification of Hazardous and Toxic Materials

A. Chemical Laboratory

The Faculty of Mathematics and Natural Sciences of Chemical Laboratory has many materials available for both practicum and research activities. The presence of activity in the laboratory using chemicals will inevitably produce a product often known by the name of waste (Harjanto and Bahri, 2019). Safe storage in lockers and accompanying MSDS constitutes a potential hazard prevention effort in the laboratory. The following are the results of identifying a number of hazardous and toxic substances available and used in research activities in Faculty of Mathematics and Natural Sciences, Sebelas Maret University laboratories.

a. Materials Give Rise to Corrosive

Table 1

List of Materials Causing Corrosive in Laboratories

Identification			
NO	Material	Laboratory	Amount
1.	CHCl ₃	Biological Organic Chemical	30 ml
2.	H ₂ SO ₄	Biological Organic Chemical, Basic Chemical II, Organic Chemical II, Biochemical, Pharmaceutical Analytical Chemical	1015,5 ml
3.	H ₃ PO ₄	Pharmaceutical Analytical Chemical	8,2 ml
4.	HCl	Basic Chemical II, Pharmaceutical Analytical Chemical, BioChemical, Basics of Spectrometric Analysis	660 ml
5.	HClO ₄	Pharmaceutical Analytical Chemical	3 ml
6.	HNO ₃	Pharmaceutical Analytical Chemical, Basics of Spectrometric Analysis, BioChemical, Inorganic Chemical II	245 ml
7.	KOH	Pharmaceutical Analytical Chemical	7,5 gr
8.	Na ₂ SO ₄	Pharmaceutical Analytical Chemical, Inorganic Chemical II	61 gr
9.	NaOH	Biological Organic Chemical, BioChemical, Basic Chemical II, Physics Chemical I, Pharmaceutical Analytical Chemical	288,5 gr
10.	NH ₃	Pharmaceutical Analytical Chemical	50 gr
11.	ZnCl ₂	Pharmaceutical Analytical Chemical	20 gr

Source: Chemical Laboratory Data of Faculty Mathematics and Natural Science, Sebelas Maret University (2011)

From table 1. it can be seen from some of the hazardous and toxic materials present in the Chemical Laboratory it can be identified by their particular properties i.e., corrosives among them are NaOH, NH₃, and others. Corrosive properties are properties that can damage even destroying other substances in direct contact through chemical reactions.

b. Toxic Materials

Table 2

List of Toxic Substances in the Laboratory

Identification			
NO	Material	Laboratory	Amount
1.	AgNO ₃	Physics Chemical I, Pharmaceutical Analytical Chemical	90,9 gr
2.	BaCl ₂	BioChemical, Pharmaceutical Analytical Chemical	220 gr
3.	CaCl ₂	Pharmaceutical Analytical Chemical, Basics of Spectrometric Analysis	7,52 gr
4.	CuSO ₄	Pharmaceutical Analytical Chemical, Basics of Spectrometric Analysis, Inorganic Chemical II	382,2 gr
5.	HCl	Basic Chemical II, Pharmaceutical Analytical Chemical, BioChemical, Basics of Spectrometric Analysis	660 ml
6.	HNO ₃	Pharmaceutical Analytical Chemical, Basics of Spectrometric Analysis, BioChemical, Inorganic Chemical II	245 ml
7.	KBr	Pharmaceutical Analytical Chemical	24 gr
8.	MgCl ₂	Inorganic Chemical II	9 gr

Source: Chemical Laboratory Data of Faculty Mathematics and Natural Science, Sebelas Maret University (2011)

From table 2. it can be seen from some of the hazardous and toxic material wastes present in the Chemical Laboratory it can be identified by their particular properties i.e., toxicities among them are AgNO₃, MgCl₂ and others. Poisonous materials are materials that have substance content with toxic properties that can cause poisoning, sickness, and death.

c. Combustible Materials

Table 3

List of Combustible Substances in the Laboratory

Identification			
NO	Material	Laboratory	Amount
1.	Alcohol	Inorganic Chemical II	330 ml
2.	Cu	Inorganic Chemical II	120 cm

Source: Chemical Laboratory Data of Faculty Mathematics and Natural Science, Sebelas Maret University (2011)

From table 3. it can be known from some of the hazardous and toxic material wastes present in the Chemical Laboratory it can be identified by their particular properties i.e., flammable substances among which are Cu and alcohol. Flammable substances are combustible substances caused by contact with air, fire, water, or other materials even in standard temperature and pressure.

d. Easily Oxidized Materials

Table 4

List of Easily Oxidized Materials in the Laboratory

Identification			
NO	Material	Laboratory	Amount
1.	H ₂ O ₂	Basic Chemical II	100 ml
2.	H ₂ SO ₄	Biological Organic Chemical, Basic Chemical II, Organic Chemical II, BioChemical, Pharmaceutical Analytical Chemical	1015,5 ml

Source: Chemical Laboratory Data of Faculty Mathematics and Natural Science, Sebelas Maret University (2011)

From table 4. it can be known from some hazardous and toxic material wastes present in chemical laboratories it can be identified by their particular properties i.e. easily oxidized among them are H₂SO₄, H₂O₂, and others. Properties of easily oxidized materials are those that can release heat due to oxidization so as to cause fire while reacting with other materials.

B. Pharmaceutical Laboratory

At the Pharmaceutical Laboratory Faculty of Mathematics and Natural Sciences, Sebelas Maret University has several management laboratories and is separated based on practical utility, among them are the Pharmaceutical Technology Laboratory, Pharmaceutical Biology Laboratory, Pharmacology Laboratory, Pharmaceutical Chemical Laboratory, and Clinical Laboratory. Based on the results of interviews with laboran located in the laboratory stated that laboratory rooms with potential hazardous and toxic material waste are found in the Pharmaceutical Chemical Laboratory and the Pharmaceutical Technology Laboratory. The following is an identification table of materials contained in the two laboratories.

Table 5
Hazardous and Toxic Substances Contained in the Pharmaceutical Laboratory

NO	Identification		
	Material	Characteristic	Amount
1.	Aniline	Irritation	1000 ml
2.	Antalgin	Toxic	1000 tab
3.	Anthraquinone	Deployingan allergy	500 ml
4.	Benzyl alcohol	Irritation	1000 gr
5.	Calcium hydroxide	Irritation dan corrosionf	1000 gr
6.	Cetamagkrogoli	Corrosive	1 kg
7.	Chloramphenicol	Toxic dir and Iritasi	25 gr
8.	Citric Acid	Irritation	1000 gr
9.	Dicalcium Fosfat Anhidrat	Toxic	1000 gr
10.	Dichloromethane	Irritation	2500 ml
11.	Ethanol	Easy burn, iritation	20 L
12.	Glyceryl Guaiacolate	Toxic	1000 tab
13.	Kalium Hidroksida	Corrosive	1000 gr
14.	Kalsium klorida (CaCl ₂)	Toxic, causing irritation, causing burns	1000 gr
15.	Methyl Salisilat	Toxic	1000 ml
16.	Natrium Carbonat (Na ₂ CO ₃)	Irritate eyes and skin with burns	1000 gr
17.	Natrium Hidroksida (NaOH)	Corrosive and cause burns	1000 gr
18.	Paraffin Liq	Irritation	1000 ml
19.	Salicylic Acid	Irritation	1000 gr
20.	Sulfur Praecipitatum	Irritation	1000 gr

Source: Pharmaceutical Laboratory Data of Faculty Mathematics and Natural Science, Sebelas Maret University (2021)

Out of 187 the amount of ingredients contained in the Pharmaceutical Laboratory was found to be 20 that have harmful and toxic properties. The nature to which the material belongs is identified using the MSDS contained in the laboratory. The quantity or quantity of the size of the material

is outlined through a purchase list of the required items upon use of the laboratory. It can be inferred from Table 5 above, that the Pharmaceutical Laboratory has a considerable amount of hazardous and toxic substance.

3.2 Identification of waste management process of hazardous and toxic materials

Hazardous and toxic material waste is defined as the remainder of an activity that has a hazardous and toxic material content (Putra et al., 2019). The management of hazardous and toxic material wastes is a series of activities covering the reduction, storage, packaging, collection, utilization, treatment, and transportation of hazardous and toxic material wastes (Indonesian State Government Regulation No. 101 Year 2014). The management of hazardous and toxic material waste needs to pay careful attention to the hierarchy of management of hazardous and toxic material waste so that any person or business operator who produces hazardous and toxic material waste is obliged to manage the generated hazardous and toxic material waste (Sidik and Damanhuri, 2012). In order to ensure the proper management of hazardous and toxic material wastes and the ease of supervision, each hazardous and toxic material waste management activity shall obtain a license issued by the Regent/Mayor, Governor or the Ministry of Environment and Forestry pursuant to the relevant provisions. The purpose of waste management of hazardous and toxic materials is to prevent and cope with pollution or environmental damage caused by waste of hazardous and toxic materials, restore polluted environmental quality, and re-fulfill its functions.

1. Reduction

Reduction of hazardous and toxic material waste is a hazardous and toxic material waste generating activity to reduce the amount or reduce the hazard properties and toxic properties of hazardous and toxic material waste before it is generated from an activity or effort. Reduction may be made through substitution of materials, modification of processes or use of environmentally friendly materials (Indonesian State Government Ordinance No. 101 Year 2014).

From the data already obtained through interviews in Laboratory of Chemical Department and the Pharmaceutical Department at the Faculty of Mathematics and Natural Sciences, Sebelas Maret University, the reduction in the amount of hazardous and toxic material waste generated was made by minimizing the use of both the concentration side and the amount of materials used, thus using the smallest concentration. The provision of chemicals for practicum and research activities comes from faculty according to the established Standard Operating Procedure (SOP). In reducing the amount of harmful and toxic materials by minimizing both the use of concentration and the amount of materials, both the use of concentration and the amount of materials are jointly carried out with an assistant in the preparation of a device for pruning by applying laboratory work safety. This is done in order to conduct practice, testing, research, or learning as needed and minimize the risk of harm to the practice and the environment.

2. Storage

Storage of hazardous and toxic material waste is the activity of temporarily storing hazardous and toxic material waste until the amount is sufficient for transportation or disposal. This was done for consideration of economic

efficiency. Storage should take into account the type and quantity of hazardous and toxic materials produced (Rahmawati and Alpiana, 2018). According to Indonesian state Government Regulation No. 101 In 2014, the hazardous and toxic material waste storage site of a building must have the least requirement of existing illumination and air ventilation and be capable of protecting hazardous and toxic material waste from rain and sunlight. In addition, it also has drainage channels and reservoirs and there are fire extinguishers, as well as other appropriate emergency countermeasures. For storage place requirements of tanks or containers made of materials corresponding to waste hazardous and toxic materials to be stored and must be in good condition, not corroded, undamaged, and not leaked.

Hazardous and toxic materials waste generated in the Laboratory Chemical Department and Laboratory of Pharmaceutical at the Faculty of Mathematics and Natural Sciences, Sebelas Maret University, laboratory are initially stored on a tank on which waste transport is then carried out by a 3rd party. The storage of hazardous and toxic material waste on both laboratories is managed in the same way. The storage of hazardous and toxic material waste is categorized by its nature, i.e., liquid waste and solid waste. Liquid waste is classified according to the prepared characteristics on the storage tank. The hazardous and toxic material waste storage tanks are already labeled according to their characteristics so as to facilitate in grouping. Whereas solid waste has a special place given for transportation. The storage of hazardous and toxic material waste in the laboratory is carried out within a period of one month, depending on the 3rd party that will transport such waste, usually the transportation of hazardous and toxic material waste is carried out every month. Within the laboratory there is information or knowledge that the implementer should know in the laboratory contained in the Material Safety Data Sheet (MSDS) to maximize the use of materials and improve health and safety and environmentally friendly standards.

3. Packaging

Packaging of hazardous and toxic material waste is a way of placing or housing hazardous and toxic material waste for convenience in storing and transporting hazardous and toxic material waste, making it safe for the environment and human health. Furthermore, packaging of hazardous and toxic material waste can prevent the formation of harmful compounds or reduce deformation as a result of reaction with the contained hazardous and toxic material waste (Wardhani and Rosmeiliyana, 2020). Materials used for packaging and other means are selected based on the characteristics of the waste generated.

As per the data obtained from interviews in the Laboratory of Chemical Department and Laboratory of Pharmaceutical at the Faculty of Mathematics and Natural Sciences, Sebelas Maret University, packaging carried out in both laboratories was stored in tanks on the condition that it did not cause a reaction that could cause gas, toxic vapor, heat, or explosion. The tanks used in packaging shall be compatible or not reacted with hazardous and toxic material waste. Any waste packaging of such hazardous and toxic materials shall be given a symbol and labeled according to the characteristics of the wastes housed. After packaging in the tank, the tank was repackaged using a yellow cardboard box equipped with the name Biohazard

to mark that inside the cardboard box there was harmful and toxic waste to be transported by the 3rd party.

4. Collection

Waste hazardous and toxic materials are not all generating parties, at once possessing for processing, utilization, or stockpiling. Matters relating to further treatment of hazardous and toxic material waste are often granted third parties who have permission and meet the criteria and provisions for being able to do so. Before submission to a third party for further processing is carried out first collection. Collection of hazardous and toxic material waste is the activity of collecting hazardous and toxic material waste from the generators of hazardous and toxic material waste before being handed over to the beneficiary of hazardous and toxic material waste, the treatment of hazardous and toxic materials waste, and/or the hoarding of hazardous and toxic materials waste. This hazardous and toxic material waste collection activity may be carried out by both the producer himself and the other party performing the collection activity. In waste collection hazardous and toxic materials are essentially performing sorting and storage. According to (Utami and Syarifudin, 2018), hazardous and toxic material waste also needs to be recorded regarding the amount and type of waste. Seeding waste hazardous and toxic materials to avoid being mixed, and storage is maximum 7 days after garbage is generated. Waste of hazardous and toxic materials generated in the laboratory Faculty of Mathematics and Natural Sciences, Sebelas Maret University, its collection activities are directly handed over to third parties. In the process of collecting hazardous and toxic material waste, the officer handling using gloves only does not use APD completely. As well as the condition of the waste collection place not being well maintained, the room did not have doors and windows and was just left open.

5. Utilization

Waste as a side product of an activity will always exist, waste will always exist in every system. It is impossible if waste is desired not to exist, but it is not wise also when existing waste is not managed with responsibility. Hazardous and toxic substances do not mean that they cannot be waste utilized, this also applies to hazardous and toxic material waste. Surely because it has higher potentially destructive potential than other wastes, hazardous and toxic material waste should be managed with more care. By performing reuse, recycling, or reacquisition with the aim of substituting raw materials, helper materials, or safe fuels not only for health as well as the environment as well. As it relates to materials whose nature is threatening, the process of utilizing hazardous and toxic material waste requires more attention (Sihombing et al., 2021). The Laboratory at the Faculty of Mathematics and Natural Sciences, Sebelas Maret University does not at all carry out the utilization of hazardous and toxic material waste generated, all hazardous and toxic material waste generated by the other agreed parties.

6. Processing

Hazardous and toxic materials waste that cannot be reused at the utilization process, shall its management process end at the treatment process. Faculty of Mathematics and Natural Sciences, Sebelas Maret University laboratories are not at all involved in this process, as it produces only hazardous and toxic material waste and has no facilities for the treatment of this

hazardous and toxic material waste. Then the processing is entirely left to a third party. The true treatment of hazardous and toxic material waste is a process with the ultimate goal of reducing or eliminating the overall nature of hazards and toxins. When the fundamental properties of hazardous and toxic materials are lost, waste of hazardous and toxic materials may be treated similarly to other wastes. Common hazardous and toxic material waste treatment techniques performed are thermal, solidification, neutralization, precipitation, and could also be by biological processes.

7. Carriage

Waste generated by Laboratory at the Faculty of Mathematics and Natural Sciences, Sebelas Maret University could not be handled further premises, but rather use the other party for further treatment. Therefore, in the process of transporting waste hazardous and toxic materials also have things to pay attention to. The stage of transporting hazardous and toxic material waste could be carried out with all transportation routes starting from land, sea, and air certainly with appropriate permits and provisions and the type of hazardous and toxic material waste being transported. Transported hazardous and toxic material waste must be in sealed containers, could with drums commonly used liquid waste whereas solid limbate uses lugger boxes. Waste hazardous and toxic materials in such containers shall also be labelled, regarding such waste hazardous and toxic materials and other necessary information. This transportation process is highly crucial in the process of treating hazardous and toxic material waste because it requires appropriate documents and equipment (Nurhidayanti and Arinih, 2019).

3.3 Evaluation of Hazardous and Toxic Material Waste



Fig. 3 Receptacle of waste on Pharmaceutical Laboratory, Faculty of Mathematics and Natural Sciences, Sebelas Maret University



Fig. 4 Receptacle of waste on Chemical Laboratory, Faculty of Mathematics and Natural Sciences, Sebelas Maret University

In the process of managing hazardous and toxic materials waste conducted by all laboratories in the Faculty of Mathematics and Natural Sciences, Sebelas Maret University has been in cooperation with third parties in the transport and waste treatment section because laboratories located in Faculty of Mathematics and Natural Sciences, Sebelas Maret University have not been able to conduct waste treatment of materials waste and toxic independently. In general, waste management conducted by the Chemical Laboratory and the Pharmaceutical Laboratory has the same mechanism, later hazardous and toxic materials waste will be transported and processed by a third party, namely PT. Arah Environmental Indonesia. PT Arah Environmental Indonesia is one of Indonesia's hazardous and toxic and infectious materials waste management companies that has obtained official permits as transporters, collectors, and processors for hazardous and toxic and infectious materials waste. From the data obtained regarding the management of hazardous and toxic material waste in the Chemical and Pharmaceutical Laboratory, the storage of hazardous and toxic material waste is carried out in a single room with the laboratory. Waste generated from practicum activities is stored inside a waste site that is a dirigen or tank placed on the back of a laboratory. In the Chemical Laboratory the jerry cans is distinguished according to the nature or characteristics of the waste, but the labels on the jerry cans have already begun to fade and are not labeled new because laboratory officials have already memorized the functions of each of the jerry can. As for Pharmaceutical Laboratories, waste storage is also carried out inside jerry cans and has been labeled, but waste storage is not differentiated based on its characteristics only differentiated according to the form of waste, i.e., liquid waste and solid waste. In addition, on transportation or collection of waste before treatment by PT. Arah Environmental Indonesia, laboratory officials carry waste hazardous and toxic materials using Self-Protective Devices (APD), such as gloves. At those laboratories also have not conducted any inventory of hazardous and toxic material waste that has been generated. This inventory aims to evaluate policies in waste management of hazardous and toxic materials (Sidik and Damanhuri, 2012). Inventory regarding the types and quantities of hazardous and toxic material waste generated by laboratories should be conducted regularly (Setiawati et al., 2019).



Fig. 5 Hazardous and toxic material waste management system in laboratory at the Faculty of Mathematics and Natural Sciences, Sebelas Maret University



Fig. 6 Hazardous and toxic material waste management system in laboratory at the Faculty of Mathematics and Natural Sciences, Sebelas Maret University

The hazardous and toxic materials waste management system in Laboratory at the Faculty of Mathematics and Natural Sciences, Sebelas Maret University can be said to be not yet well prepared and there is no good management system, structured, systematic, and without any adequate technological input. The waste management found in these laboratories still needs to be improved, so there are several solutions that can be done to make waste management of hazardous and toxic materials in the Chemical and Pharmaceutical Laboratory at the Faculty of Mathematics and Science Sebelas Maret University even better. The first solution is to build or prepare a single room specially designed for temporary storage of hazardous and toxic material waste so that temporary storage of hazardous and toxic material waste is not in a single room with a laboratory. In addition, with regard to labeling hazardous and toxic material waste for the Chemical Laboratory a new label shall be given to each jerry containing hazardous and toxic material waste. As for Pharmaceutical laboratories, the temporary storage of hazardous and toxic material waste is not only distinguished regarding solid and liquid waste but is distinguished also on the properties and characteristics of hazardous and toxic material waste generated. The final solution regarding the management of hazardous and toxic material waste in the Chemical and Pharmaceutical Laboratory is before the hazardous and toxic material waste is transported and treated 3rd party can be carried out management by each laboratory in advance so that the resulting hazardous and toxic material waste is not too much.

4. Conclusion

From the observation results that have been conducted at the Laboratory of Chemical Department and Laboratory Pharmaceutical at the Faculty of Mathematics and Natural Sciences of the Sebelas Maret University, it is known that the classification and characteristics of hazardous and toxic materials waste consist of corrosive, toxic, flammable, and easily oxidized. Waste hazardous and toxic materials having corrosive characteristics are sodium hydroxide, sulfuric acid, and hydrochloric acid. Waste hazardous and toxic materials having toxic characteristics are silver nitrate and copper (II) sulfate. Waste materials hazardous and toxic materials that have flammable characteristics are alcohol and copper. Waste hazardous and toxic materials that have easily oxidized characteristics are hydrogen peroxide and sulfuric acid. Whereas the general hazardous and toxic material waste management systems found in the Pharmaceutical and Chemical laboratories of the Faculty of Mathematics and Natural Sciences of the Sebelas Maret University are reduction, storage, packaging, collection, utilization, processing, and transportation. The transportation and processing part management is done in cooperation with the third party, namely PT. Arah Environmental Indonesia.

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