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Evaluation of the Liquid Medical Hazardous and Toxic Waste Management System at X Hospital Palembang

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Abstract: The problem of managing medical hazardous and toxic waste still becomes an obstacle faced by most hospitals, due to the limited facilities, infrastructure, manpower, and of course the very large funds required. X Hospital Palembang has implemented a liquid medical hazardous and toxic materials waste management system at the Wastewater Treatment Plant (WWTP) using the aerobic filter method. This research aimed to evaluate the liquid medical hazardous and toxic waste management system carried out at X Hospital Palembang and whether it follows the Indonesian Minister of Health Regulation Number 7 of 2019 concerning Hospital Environmental Health. It also hoped that it can help provide assessments for the accreditation programs. This research was conducted using interviews, field observations, and laboratory tests such as bioassay (BOD) to measure the effects of a substance on a living organism, the chemical oxygen demand (COD) to measure the number of organic pollutants in a water body as an indicator of water quality, total dissolved solids (TDS) to find out the measurement of the total amount of dissolved organic and inorganic content present in water, the total suspended solids (TSS) to determine the operational behavior of a waste treatment system, oil and fat test to identify the presence of oils and fats in the given sample, a methylene blue active substances assay (MBAS) to detect the presence of anionic, ammoniacal nitrogen (NH_3-N) to find out the amount of ammonia in waste products, and literature studies. Based on the research results, almost all processes in the liquid medical hazardous and toxic waste management system are in accordance with regulations. However, it needs to be corrected that the liquid waste quality test needs to be done at the beginning of the month; then analysis and follow-up are carried out if there are quality standards that do not fill the requirements. DO check has not been done for daily self-monitoring of liquid waste quality. Health checks, routine vaccinations, and special training for waste management officers have not been done.
Keywords: evaluation, hazardous and toxic materials, management system

1. Introduction

The hospital is a health service institution that provides complete individual health services that provide inpatient, outpatient, and emergency room services [1] [2]. The hospital as a health service facility, a gathering place for sick and healthy people, or can be a place for disease transmission and allows environmental pollution and health problems [3]. Hospitals include producers of waste originating from medical and non-medical activities that have hazardous and toxic properties in large quantities and have a large impact on the surrounding environment. As a facility that provides health services to the community, hospitals have an obligation to manage Hazardous and toxic materials category medical waste appropriately and in accordance with the regulations related to medical hazardous and toxic materials waste [4]. If not handled properly, poor waste management contributes to climate change, and air pollution, and directly affects many ecosystems and species. The management of hospital medical and non-medical waste is certainly very necessary for the comfort and sanitation of hospitals since it can break the chain of the spread of infectious diseases, especially nosocomial infections [5]. The existence of waste as the results of hospital operations requires proper and correct management. The results of the study of hospital waste treatment in Indonesia show that most medical waste management does not fill the requirements according to regulations [6]. Hospital waste is waste generated by hospital activities and other supporting activities that produce medical and non-medical waste; both solid and liquid which can cause disease and environmental pollution that need special attention [7]. Waste is any substance discarded after primary use, or is worthless, defective and of no use in the form of liquid or solid

substances containing hazardous and toxic materials which due to their nature and concentration or amount can directly or indirectly pollute or damage the environment, and endanger the environment, health, survival of humans and other living creatures. [8]. Medical hazardous and toxic materials waste management is carried out with the principle of vigilance and using safe and environmentally friendly waste management methods. Each installation must have a clear division of labor to coordinate and improve the quality of a good medical waste management system [9]. Waste pollution cannot be eliminated, but can be minimized by means of effective and efficient processing thus the burden of pollution entering the environment can be reduced. Management of Hazardous and toxic materials waste, especially medical Hazardous and toxic materials waste is one of the most serious problems experienced in health facilities since medical waste, especially infectious waste, is very potential in transmitting infectious diseases either through direct or indirect contact through environmental media. [10]. Since the medical waste management system is an important way to control sources of infection, standardization, and strict application of medical waste management, especially related to the Covid 19 pandemic, it must be done carefully with consideration to reduce the risk of rapid transmission in hospitals. [11].

X Hospital Palembang is a hospital owned by the local government of Palembang city, is a type B hospital with plenary accreditation, with a total of 320 beds. X hospital Palembang provides services including: outpatient, inpatient, emergency room, delivery, surgical oncology, intensive care, and referral from type C health center in Palembang city, Multy Drug Resistent Tuberculosis poly, hemodialysis, covid patients, radiology, laboratory, pharmacy, and other supporting services. As a health service facility, X Hospital Palembang is required to provide excellent health services to the community, both in terms of quality of health services, as well as in maintaining environmental quality, including in terms of managing waste generated from service activities that are very harmful to the community.

The Environment around the hospital, hospital visitors, and even employees in the hospital environment. For this reason, it is necessary to optimize the B3 waste management system that is effective, efficient, and in accordance with health protocols to ensure the health, safety and security of visitors, employees, and the community around the hospital environment. [11].

This research aims to determine the effectiveness and efficiency of the liquid medical hazardous and toxic waste management system at X Hospital Palembang in terms of the efficiency of the use of available resources (funds, manpower, facilities, and infrastructure), suitability in program planning and the impact of program implementation, and suitability in the procedures and technical requirements of the liquid medical hazardous and toxic waste management system starting from the initial process of producing waste to the final process of processing waste whether it is in accordance with the applicable laws and regulations, namely Permenkes Number 7 of 2019 concerning Hospital Environmental Health.

2. Materials and Methods

2.1. Materials

The tools used in this research are voice recorder, camera for documentation, discharge measuring device, checklist/form, hazardous and toxic materials waste logbook, questionnaire sheet, glass bottle, etc. The study was conducted from June to August 2022 in the work environment and WWTP of X Hospital Palembang.

2.2. Methods

The methods used in this study were interviews, filling out questionnaires, field observations, laboratory tests, and documentation studies/literature studies. The type of research carried out is observational with a qualitative descriptive approach and comparative descriptive approach, based on a cross-sectional approach to research time. With purposive sampling method consisting of main informants and triangulation informants. Field observations were undertaken every day by observing the process of processing liquid medical hazardous and toxic material wastes starting from the process produced from each producer of liquid waste sources to the one being processed at the WWTP.

Questionnaires were also distributed to field implementing officers and sanitation officers, as well as interviews with the head of the WWTP installation and hospital chief. The questionnaire consisted of several question items related to the officer's tenure, job position, and training they had attended while on duty, and vaccines and health checks they obtained while on duty. In addition, the volume of wastewater discharge entering the inlet and outlet tubs is also recorded for 24 hours and recorded in a logbook, in order to see the trend of discharge. Field observations were done to observe directly the process of the liquid medical hazardous and toxic waste management system at the WWTP of X Hospital Palembang.

2.3. Data Analysis

Primary and secondary data were used in this study. The field observations were administered to observe directly the process of the liquid medical hazardous and toxic waste management system at the WWTP of X Hospital Palembang. Evaluation of liquid medical hazardous and toxic materials waste management was conducted by comparing the data derived from field observations, questionnaires, recordings, and interviews

dealing with the Regulation of the Minister of Health Number 7 of 2019 concerning the Hospital Environmental Health.

3. Results and Discussions

3.1. Result of Interview and Observation of Liquid Medical LB3 Management System

3.1.1. Sources of liquid medical waste

Source of liquid medical waste of X Hospital Palembang came from the medical service room and the support service room. These included the Emergency Room, Intensive Care Room (ICU, ICCU, NICU, and PICU), Surgery Room, Midwifery Room, Outpatient Polyclinic, Laundry Installation, Central Sterile Supply Department, Pharmacy Installation, Nutrition Installation, Funeral Installation, Radiology, Hemodialysis, and Laboratory.

Liquid waste flow system with closed piping, and separate between rainwater and wastewater channels. Wastewater flows from each room to the control tub/chopstick tub located in each room to the WWTP with a gravimetric system. There are some that flow by using a pump, usually due to uneven or higher ground. The wastewater from all rooms flowed gravimetrically to the Wastewater Treatment Plant as the ground surface was tilted; therefore, there was no need to use a pump. However, there were several sources of liquid waste from several rooms where the soil conditions were indeed uneven, therefore a pump was needed to drain it, for example, the liquid waste from the Emergency Room and Medical Rehabilitation Room. The same thing can be found in Hospital X Bandung City, in the research of Fillya Vallyana et al (2022), where the process of chanelling wastewater to the WWTP is carried out using a gravimetric system, and assisted by a pumping machine to drain the waste.

3.1.2. Liquid Waste Treatment Units

The wastewater treatment system implemented at the X Hospital Palembang is using WWTP with the aerobic filter method. From several sources of liquid waste generating rooms, there are 3 rooms where before the waste water is channeled to the WWTP, initial treatment must be done, thus as not to interfere with the treatment system at the WWTP. The three rooms are the Nutrition Installation, Laundry Installation, and Laboratory Installation. Wastewater coming from the Nutrition Installation is pre-treated in the form of a grease trap because from this room there are a lot of food and vegetable residues that will clog the channel. For this reason, before being channeled into the WWTP, the liquid waste from this nutrition installation passes through the fat catcher tank first thus as not to interfere with the processing process at the WWTP.

At the Laundry Installation, before the wastewater is drained, initial processing is done at the PTB laundry where the remnants of detergent, fiber, or thread from the fabric are first filtered in this tool thus as not to clog the channel and interfere with the processing process at the WWTP. Likewise, liquid waste originates from the laboratory, where liquid waste from the laboratory contains a lot of hazardous chemicals and heavy metals which will interfere with the wastewater treatment process at the WWTP. Wastewater from the laboratory is first treated in HMP (Heavy Metal Precipitator) with the addition of acid and polymer materials with a certain dose in accordance with the manufacturer's regulations to neutralize chemicals, heavy metals, and very dangerous toxicants. After processing in the initial treatment, then it was directed toward the WWTP channel for further processing. This is in accordance with the directives in the Minister of Health Regulation No. 7 of 2019 concerning Hospital Environmental Health related to the Implementation of Safeguarding Liquid Waste.

Different things were found in research conducted by Khamidah, et al (2018) on the quality of wastewater in several Pekanbaru city health centers. Where the liquid waste originating from the kitchen and laundry is not equipped with a grass trap, thus it can interfare with the wastewater treatment process, due to a blockage of the pipeline by waste from the kitchen and laundry which is not filtered first. This resulted in the treatment process not running optimally, and affecting the quality of several wastewater parameters including the MBAS parameter, as well as the oil and lipid content of the wastewater.

3.1.3. Wastewater Treatment Process at X Hospital Palembang

The wastewater treatment system is done at X Hospital Palembang using an aerobic bacteria filter, where a suspension of aerobic bacteria is used which oxygen is added for the growth of these germs. The bacterial suspension was prepared by the waste management officer by mixing the bacterial powder provided by the supplier with clean water and wastewater, with a composition of 100 grams of bacterial powder added to 1 liter of clean water and 1 liter of wastewater. Then the bacterial suspension was incubated for 24 hours, after which it was slowly put into the aeration tank to help process wastewater treatment in the WWTP carriage. The following is a flow chart of the liquid waste treatment system at the WWTP at X Hospital Palembang.

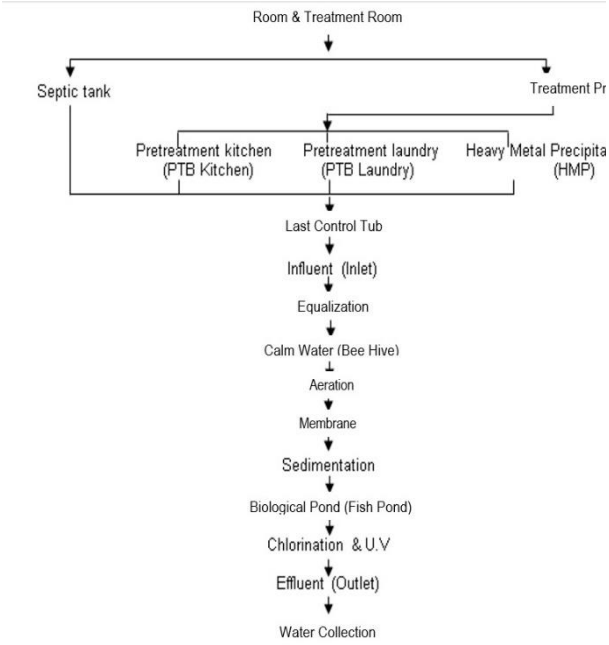

Figure 1. Processing System Flowchart in Waste Water Treatment Plant at X Hospital Palembang

From each source room for liquid waste, the wastewater flows gravimetrically to the final collection pack, where it will then flow to the equalization tank. Waste originating from each room is accommodated in the control tank, except in the 3 places mentioned above. In these three places, before being channeled to the inlet, the waste is treated with additional equipment.

At the nutrition installation, there is a fat catcher / PTB (Pre Treatment Bone) to filter and catch food waste thus it doesn't clog the pipelines. Waste from the laboratory contains a lot of chemicals, therefore it must be neutralized first in the HMP (Heavy Metal Precipitator) with the addition of acid and polymer powder. Before being added to the HMP apparatus, the acid and polymer powder used for this neutralization was first made into a suspension by diluting it using a ratio of 1 tablespoon of acid or polymer powder and then adding 1 liter of distilled water or plain water. After that, the liquid was put into a small tank on the HMP tool for the process of neutralizing laboratory wastewater.

In the laundry, there is also PTB before the waste was accommodated at the inlet. At this inlet, the daily pH measurements were carried out using litmus paper. At this inlet, wastewater samples are taken once a month to be examined in the laboratory checked for BOD and COD levels at the Regional Environment Agency. Furthermore, from the inlet, the wastewater flows into the equalization tank to mix all the waste from the entire room. Next to the aeration tank, a blower is used here and aerobic bacteria are given to reduce the levels of BOD and COD in wastewater. Then it goes to the sedimentation/active mud tank, where all the mud is trapped, once every 6 months this tank is drained, and then the sediment that has settled is dried in the drying bed and then burned in the incinerator, thereby reducing the TSS value of the wastewater. Then go to the bioindicator tank where koi fish are given here as an indicator that the wastewater here is clean. After that, go to the UV pool, where chlorine is given as a disinfectant and UV irradiated, then it flows into the outlet, and finally, it can flow directly into the water body/river.

3.1.4. Evaluation of Liquid Waste Quality Test Results

Table 1 and Table 2 showed that the results of laboratory tests of liquid waste at the WWTP of the X Hospital Palembang in July and August were obtained for all test parameters including: temperature, TDS (Total Dissolved Solids), pH, COD, BOD5, TSS (Total Suspended Solid), Oil/Fat, NH3N, and Total Coliform all comply with the wastewater quality standards, namely the Regulation of the Minister of Environment and Forestry No.P.68/MENLHK/Setjen/KUM.I/8/2016 concerning the Hospital Liquid Wastewater Quality Standards.

Table 1. Liquid Waste Laboratory Test Results in July 2022

Parameter	Unit	Grade		% Reduction	Maximum Rate	Test Method
		Inlet	Outlet			
Temperatur	^{0}C	30.1	30.1		-	SNI 06-6989.23-2005
TDS	mg/l	154.2	182.4	15,4 %	-	ELEKTRO KIMIA
pH	-	6.84	7.06		6 - 9	SNI 6989.11-2019
COD	mg/l	158.6	57.61	63,7 %	100	SNI 6989.2-2019
BOD_5	mg/l	125.4	20.98	83,2 %	30	SNI 6989.72-2009
TSS	mg/l	54	13	75,9 %	30	SNI 6989.3-2019
Oil and Fat	mg/l	2.6	0.6	76,9 %	5	IK No.15.4/IK/LLK/2021
MBAS	mg/l	0.342	0.208	39,1 %	-	SNI 06-6989.51-2005
NH_3N	mg/l	22.3	0.237	98,9 %	10	SNI 06-6989.30-2005
Total Coliform	MPN/100 ml	1100	74	93,2 %	3000	SNI 01-2897-1992

Table 2. Liquid Waste Laboratory Test Results of August 2022

Parameter	Unit	Grade		% Reduction	Maximum Rate	Test Method
		Inlet	Outlet			
Temperatur	^{0}C	30.1	30.1		-	SNI 06-6989.23-2005
TDS	mg/l	254	148.2	15,4 %	-	ELEKTRO KIMIA
pH	-	6.75	7.21		6 - 9	SNI 6989.11-2019
COD	mg/l	525.7	57.10	63,7 %	100	SNI 6989.2-2019
BOD_5	mg/l	418.0	21.02	83,2 %	30	SNI 6989.72-2009
TSS	mg/l	112.6	3.2	75,9 %	30	SNI 6989.3-2019
Oil and Fat	mg/l	6.2	0.5	76,9 %	5	IK No.15.4/IK/LLK/2021
MBAS	mg/l	0.170	0.182	39,1 %	-	SNI 06-6989.51-2005
NH_3N	mg/l	18.5	0.181	98,9 %	10	SNI 06-6989.30-2005
Total Coliform	MPN/100 ml	1100	120	93,2 %	3000	SNI 01-2897-1992

Notes :
MPN = Most Probable Number
MBAS = Methylen Blue Activated Surfactan

From the wastewater inspection data taken from the inlet and outlet, it can be seen that the temperature was stable, the pH of the wastewater slightly increased after leaving the outlet, the Total Suspended Solid parameter (TSS) decreased by 75% in July and 97,1% on August. The process can occur due to sedimentation in the sedimentation tank. This is in line with Arifin's research (2019), stating that the waiting time for the deposition process is a supporting factor in the wastewater treatment process. The TSS value of wastewater from the inlet to the outlet decreased after being processed in the sedimentation tank with the formation of activated sludge; all sludge was retained here, thus the waste that came out was clearer. The COD levels and BOD decreased from the inlet to the outlet after being processed from the aeration tank due to the addition of aerobic bacteria that decomposed polluting organic matter [12]. The decrease in the BOD level in July was 83,2% and in August it was 94,5%. This resulted from the process of settling suspended particles[16]. The total Coliform showed a very drastic decrease in numbers, there was a decrease of 93,2% in July and 89,0% in August, due to the application of chlorine and UV light in the UV pool [13]. This is due to the provision of chlorine and UV light as a disinfectant which damaged bacterial cells, impaired cell permeability, and damaged nucleic acids and enzymes in bacteria thus they killed these bacteria. It can be concluded that the wastewater treatment process carried out at X Hospital South Sumatra has been going well, the waste produced has met the quality standards of hospital liquid waste, therefore it is safe to flow into water bodies and does not interfere with the health of the community around the hospital.

3.1.5. Evaluation of Wastewater Discharge Trend

Table 3. The Average Wastewater Discharge Value

Month	June		July		August	
	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet
	5.85m^3/ hour	5.72m^3/ hour	5.5m^3/ hour	5.47m^3/ hour	5.82m^3/ hour	5.71m^3/ hour

The recording of the daily average wastewater discharge at the inlet and outlet tanks (Table 3) which were generated from several sources of liquid waste, the average waste discharge in June was 5.85 m^3/hour (inlet) and 5.72 m^3/hour (Outlet), in July the average was 5.5 m^3/hour at the inlet and 5.47 m^3/hour at the outlet, in August the average was 5.82 m^3/hour (inlet) and 5.71 m^3/hour (outlet). The trend of the average discharge of wastewater entering through the inlet into the WWTP machine is still in accordance with the design of the WWTP hydraulic load for treating wastewater. The design capacity of the WWTP hydraulic load is 8.3 m^3/hour.

To anticipate the excess capacity of wastewater discharge that enters the WWTP tank, an indicator pipe has been prepared in the WWTP equipment carriage, where wastewater that exceeds the maximum discharge limit, will enter through the indicator pipe and flow back into the equalization tank and return to the initial stage of processing. This is different from the research by Ninggrum and Khalista (2014) which was conducted at X Jember Hospital, where waste water that exceeded the capacity of the holding tank was overcome by increasing the capacity of the bake rob reactor, you can also add a septic tank to accommodate waste from the bathroom.

3.1.6. WWTP Efficiency Evaluation

The purpose of this evaluation is to determine the ability of the WWTP system to reduce the concentration of certain wastewater parameters in conditions before and after the process. This evaluation can be used as a benchmark for the success of the

WWTP operational and maintenance program.
WWTP efficiency in June:

$$\text{Efficiency} = \frac{BOD\ Inlet - BOD\ outlet}{BOD\ Inlet} \times 100 \qquad (1)$$

$$\text{Efficiency} = \frac{115{,}5 - 21{,}05}{115{,}5} \times 100\%$$

= 81,7 %

WWTP Efficiency in July :

$$\text{Efficiency} = \frac{125{,}4 - 20{,}98}{125{,}4} \times 100\%$$

= 83,2 %

WWTP Efficiency in August :

$$\text{Efficiency} = \frac{418{,}0 - 21{,}02}{418{,}0} \times 100\%$$

= 94,9 %

Table 4. WWTP Efficiency Value

Month	BOD Inlet	BOD Outlet	Efficiency
June	115,5	21,05	81,7%
July	125,4	20,98	83,2%
August	418,0	21,02	94,9%

From the measurement of the efficiency of the WWTP equipment at the X Hospital Palembang in June, July, and August, it was found that an increase in the efficiency of the WWTP equipment was found in June 81.7%, July 83.2% and August 94.9%. From the results of this efficiency measurement, it can be seen that the operational and maintenance programs conducted by the wastewater officers at the WWTP were successfully implemented. The officers regularly undertook the maintenance of facilities and infrastructure at the WWTP starting from measuring the discharge on a regular basis, draining the sludge in the equalization tank periodically every 6 months, draining the sludge in the WWTP tank, cleaning the pump in the control tank, making periodic suspension of aerobic bacteria, and draining of bioindicator ponds, e.t.c

3.1.7. Evaluation of Provisions for Management of Liquid Medical Hazardous and Toxic Waste compared to Permenkes Number 7 of 2019 concerning Hospital Environmental Health

Table 5. Evaluation Result of Medical Liquid Waste Management Provisions

No.	Provisions for Liquid Waste Management	Qualification	
		Appropriate	Inappropriate
1.	The hospital has a WWTP with the right technology and a waste treatment capacity design that is in accordance with the volume of liquid waste produced;	✓	
2.	Fulfill the quality standards of liquid waste effluent according to regulations;	✓	
3.	The WWTP is placed in the right location, namely in an area that is far away and does not interfere with hospital service activities, and is close to receiving water bodies;	✓	
4.	Fulfill the frequency of taking samples of liquid waste once a month;	✓	
5.	Fulfill compliance with reporting of laboratory test results for liquid waste to government agencies in accordance with the provisions (1 time per 3 months);	✓	
6.	The design of the WWTP treatment capacity must be in accordance with the calculation of the maximum discharge of liquid waste produced plus a safety factor of ± 10%;	✓	
7.	WWTP in the hospital must be operated 24 hours;	✓	
8.	There is a WWTP Coordinate Point Writing Board using the Global Positioning System (GPS);	✓	
9.	Liquid waste inspection is done at the beginning of the month;		✓
10.	Hospitals are required to do daily self-monitoring of wastewater with minimum parameters of DO, temperature, and pH; and		✓
11.	Routine health checks/medical check-ups, periodic vaccinations for medical B3 waste management officers, and provision of additional food/vitamins.		✓

From the data of Table 5, the evaluation of the procedures for implementing liquid waste management at X Hospital Palembang was carried out by using field observations and interviews with liquid medical waste management officers. However, there were several inappropriate things, among others: The examination of the quality test of liquid waste at X Hospital Palembang was conducted very close to the end of the month; the liquid waste quality test should have been done at the beginning of the month. This is to anticipate if it turns out that the results of the quality test of the quality of the liquid waste are not up to standard, then the liquid waste manager can analyze the cause of the incident and take follow up on the problem. The next thing is to do a quality test of the quality of the liquid waste after there is an analysis of the causes of the problem and its follow-up, at the end of the same month.

Furthermore, the hospital did not check the DO (dissolved oxygen) level as a minimum parameter for daily self-monitoring of wastewater as directed in the Minister of Health Regulation Number 7 of 2019 concerning Hospital Environmental Health. And the routine health checks and periodic vaccinations for waste management officers were not yet conducted for their personal protection. The data were derived from the results of the interview and filling in questionnaires with the waste management officers (Primary data).

Checking the DO (dissolved oxygen) parameter is mandatory since the value of this DO parameter can indicate the quality of the wastewater. The greater the DO value, the better the water quality, and vice versa. The concentration of dissolved oxygen is very important for the survival of aquatic biota such as aquatic plants and animals. While routine health checks for waste management workers are also important to carry out, bearing in mind that these waste management workers are at great risk of disease transmission due to the work they do. With routine health checks for waste management workers, diseases they get as a result of work can be detected as early as possible and treated immediately.

4. Conclusion

The liquid medical Hazardous and toxic materials waste management system implemented at X Hospital Palembang is in accordance with the applicable laws and regulations, namely Permenkes Number 7 of 2019 concerning Hospital Environmental Health, where from the results of the quality test the liquid waste quality has filled the quality standards for hospital liquid waste. The effectiveness and efficiency of WWTP equipment have also been running optimally with an efficiency rate of 94% in August, which is a benchmark for the success of the WWTP operational and maintenance program. The hospital management must think more about the risks that arise to workers managing waste due to work, by providing personnel protection in the form of routine health checks, supplementary feeding, and periodic vaccine. This is similar to H. Lemma's research at Guji Barat Hospital, that there is a lack of commitment and attention from management to waste management officers, thus affecting the effectiveness and efficiency of waste management results.

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