Implementation of cleaner production to improve wastewater treatment performance

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Abstract. Wastewater management in hospitals is needed to process wastewater generated from each hospital’s activities to reduce polluters’ burden in its disembodied. Wastewater management, in general in hospitals, applies the end of the pipe, which certainly does not completely solve existing environmental problems. The implementation of clean production is expected to improve wastewater treatment performance by identifying inefficiency opportunities in wastewater treatment and efforts to reuse processed water. The research was conducted by conducting laboratory analysis of wastewater treatment results using chemical and biological physics parameters and looking at the opportunities that can be done from the inefficient wastewater treatment described using flow diagrams. The analysis results showed that the processed wastewater from the wastewater treatment process still meets the standard requirements based on physical, chemical, and biological parameters so that it can be utilized back into raw water for hospitals. Identification of aspects found in the existence of inefficiencies is humans, methods, materials, and machinery. The application of cleaner production to provide recommendations for other hospitals to improve wastewater treatment performance as well as wastewater treatment utilization. Implementation of cleaner production to improve wastewater treatment performance through identification in each process and investigate the potential application of cleaner production that can be applied to the system.

1. Introduction
The construction of wastewater treatment in every hospital needs to be done considering that hospital waste contains hazardous materials that can pollute the environment. The requirements have been set out in Government Regulation (PP) No. 82/2001 on Water Quality Management, wastewater treatment process (WWTP) becomes a mandatory requirement for industry and public service agencies that produce liquid waste. Water consumption in the hospital is used in various places like surgery, laboratories, kitchens, etc. The process can change the characteristics of water drastically [1].

The construction of a wastewater treatment hospital should prioritize the environmental aspect and apply the principle of sustainable development so that the environmental impact can be minimized and optimize its management. Currently, in many developing countries, the importance of the sustainability of wastewater has emerged and also has become a standard practice in developed nations [2].

Given the importance of wastewater treatment role in the management of the hospital, makes wastewater treatment requirement increasing in every hospital. This should be aligned with good management. Many problems found are the lack of attention and seriousness from the management/manager of the hospital. At the moment, cleaner production is an approaching method for minimizing and initiating waste and has been used widely to minimize industrial waste in the world [3]. This motives researchers to apply cleaner production as an effort to minimize the impact of waste.
and improve environmental quality at WWTP. Hospital wastewater is all liquid waste originating from the process of all hospital activities including domestic wastewater, waste from bathrooms, kitchens, water from washing clothes, clinical liquid waste, wounds, washing blood, as well as laboratory wastewater and others [4].

Types of wastewater in health care facilities can be grouped as follows: domestic wastewater, clinical wastewater, clinical and chemical laboratory wastewater, and radioactive wastewater (not allowed to enter Wastewater treatment, must follow instructions from BATAN). The characteristics of the waste determine the performance results of the WWTP which is seen through the results of the treated wastewater that has been treated by the wastewater treatment machine. The characteristics of the waste are very dependent on the source of the waste and the activities of the waste generating. The types of materials used can change from time to time depending on the activities in these activities [5]. The characteristics of wastewater are divided into physical characteristics, chemical characteristics, and biological characteristics [6].

The parameters of the physical characteristics of wastewater include Total Solid (TS), odour, temperature, density, colour, conductivity, and turbidity. The chemical characteristics of wastewater can be tested for parameters, one of which is COD and BOD. COD (chemical oxygen demand) is the amount of oxygen needed for the waste material in the water to be oxidized through a chemical reaction. High COD numbers result in a lack of oxygen content in water bodies, which disrupts aquatic ecosystems [7]. BOD (biological oxygen demand) is an empirical analysis that tries to approach globally the biological processes that occur in water. The BOD number is the amount of oxygen required by bacteria to break down (oxidize) almost all dissolved organic substances and some substances - organic substances suspended in water. Biological characteristics are measured by microorganisms contained in wastewater including coliform bacteria and other organisms such as algae, fungi, etc. [8].

In the majority of cases, hospital wastewater is diluted with municipal sewage, and commonly causes a reduction in pharmaceutical compounds amount in the waste. Despite even in small concentration the composition could be still toxic to the environment [9]. Wastewater that is immediately disposed of without going through the processing process will have an impact on the damage to the environment and surrounding communities.

The implementation of wastewater treatment evaluation is carried out periodically which aims to determine whether the existing wastewater treatment conditions have performance effectiveness by following per under the standards or not. The parameters seen are the quality of wastewater produced must meet the quality standards [10]. The attention of most wastewater research strengthens the water quality, technical aspects, also reducing the environmental and health impacts without focusing on paying attention to their general social and sustainability dimensions [11]. The success of wastewater treatment depends on determining technology factors based on the physical and chemical characteristics of the processed wastewater, the human resources that operate it, as well as other supporting operational factors, such as cleaning methods, raw materials used, condition boost of machine facilities in the production area can also optimize the result of wastewater final treatment.

The result of recycled and reused wastewater can be used for many activities such as agriculture, firefighting, flushing of toilets, industrial cooling, park watering, the formation of wetlands for wildlife habitats, etc [12]. Clean production is an environmental management strategy that leads to prevention and integrated to minimize the impact of production and products on the environment and also implemented throughout the production cycle [13]. Clean production implementation technology is the merging of waste reduction techniques in sources with waste recycling techniques. Environmental management strategy through clean production approach aims to prevent or avoid the formation of waste [14]. The focus of this cleaner production application is to reduce waste directly from the source so that the pollution burden can be reduced and processed waste can be reused. The implementation of this clean production concept aims to provide benefits for the company as well as reduce waste management activities [15]. The successful implementation of cleaner production shown by the economic savings by lowering production costs so that there is an increase in product efficiency.
2. Material and Methods
The research was conducted at Hospital X located at Letjen S. Parman Street No.84-86, Kota Bambu Selatan, Palmerah, West Jakarta. The hospital is included in the type A hospital which has two wastewater treatment, each wastewater has a capacity of wastewater treatment I 750 m$^3$/day and wastewater treatment II 100 m$^3$/day. The research was conducted on Wednesday, September 16, 2020. The analysis is done by observing each wastewater treatment process by describing the flow diagram in each wastewater treatment. Observations were made to find the inefficient part of each wastewater treatment process. The analysis is also done by taking wastewater samples, samples are taken from two different points, namely inlets and outlets of WWTP available in hospitals. The inlet part is taken from the equalisation chamber while the outlet part is taken from the indicator pool before being discharged into the sewer. The analysis is also done by taking wastewater samples on the input and output of each wastewater treatment. Observation of wastewater samples aims to find out the level of wastewater pollution. Wastewater is then tested using physical, chemical and biological parameters. Wastewater quality results are then compared with wastewater quality standards following the requirements, namely PERMENLHK RI No. P.68/Menlhk/Setjen/Kum.1/8/2016 which can be seen in Table 1.

| Parameter     | Highest Concentration |
|---------------|-----------------------|
| pH            | 6-9                   |
| BOD           | 30 mg/L               |
| COD           | 100 mg/L              |
| TSS           | 30 mg/L               |
| Oil & grease  | 5 mg/L                |
| Ammonia       | 10 mg/L               |
| Coliform Total| 3000 (MPN/100 ml)     |
| Water Discharge| 100 L/day          |

Table 1. Raw wastewater quality for health service facility activities

Raw wastewater quality is a measure of the limit or content of contaminants and or the number of contaminants that are stretched in wastewater that will be disposed of or released into the water source of a business and or activity [16]. The determination of raw wastewater quality for industry and/or other business activities aims to measure the limits or levels of contaminants in wastewater that will be disposed of to the water source. Regulated domestic wastewater parameters include pH, BOD, COD, TSS, oil and fat [17]. The analysis is then conducted with cleaner production to find the inefficient processes as well as opportunities that could be applied to wastewater treatment to improve its efficiency and performance.

3. Results and Discussion

3.1. Wastewater Treatment System
The selection of an effective and efficient wastewater treatment technology aims to improve existing environmental sanitation quality systems. Technology that takes precedence can produce a product that can be recycled, in this case, a waste product that can be reused for various purposes [18]. The wastewater treatment system in Hospital X uses a combination of aerobic and anaerobic processing systems. The wastewater treatment system is divided into two processing plants namely wastewater treatment system I and wastewater treatment system II. Each treatment system has a different source of wastewater. The wastewater treatment system is pictured in Figure 1 and 2.
Figure 1. Wastewater treatment system I

Figure 2. Wastewater treatment system II
Figure 1 shows the source of waste processed by WWTP 1 comes from all hospital activities derived from toilets, bathrooms, sinks, urinals, laboratory waste (blood/serum/plasma, urine and remnants of reactions/reagents. Wastewater is then treated with physical treatment through grit chambers and bar screens. From bar screen, the wastewater will go to the aeration tub, in the tub of wastewater aeration will be routinely given an air supply from the blower so that aerobic bacteria can process entirely of wastewater. Wastewater derived from the aeration tub then flows to the sedimentation tub, this process is the main key of aerobic and anaerobic processes in WWTP. Wastewater derived from WWTP 2 comes from kitchen nutrition, laundry, and TPS. WWTP 2 has a pre-treatment in each source to reduce the content of pollutants before the process into the machine. WWTP 2 also uses anaerobic and aerobic systems using fine bubble diffuser and aerobic chamber with biofilm.

3.2. Wastewater treatment system results
The results of outlets contained in each wastewater treatment are then carried out laboratory tests using parameters of physics, chemical and biology which are pH, BOD₅, COD, TSS, Oil & Grease, Ammoniac, Coliform, Discharge. The results of these observations are then compared to the prevailing quality standards used in this study are PERMENLHK RI No. P.68/Menlhk/Setjen/Kum.1/8/2016. Testing is conducted on September 16, 2020. The results of laboratory analysis are described in tables 2 and 3 below.

| No | Parameter     | Unit   | Quality Standards | Results | Method                                      |
|----|---------------|--------|-------------------|---------|---------------------------------------------|
| 1  | pH (26°)      |        |                   | 7.6     | SNI 06-6989. 11-2004                        |
| 2  | BOD₅         | mg/L   | 30                | 9       | SNI 6989.72-2009                            |
| 3  | COD          | mg/L   | 100               | 47      | SNI 6989. 15-2004                           |
| 4  | TSS          | mg/L   | 30                | 10      | UP.IK.21.01.07(Spectrophotometry)           |
| 5  | Oil & grease | mg/L   | 5                 | <1.8    | SNI 6989.10-2011                           |
| 6  | Ammoniac     | mg/L   | 10                | <0.01   | SNI 6989.30-2005                           |
| 7  | Coliform     | MPN/100mL | 3.000             | <1.8   | APHA Ed. 23rd 9221.B-2017                  |
| 8  | Discharge    | L/Person/Day | 100               | -       |                                             |

The test results show that the quality of wastewater produced in Wastewater Treatment I and II is still below the standard quality. The pH value of water indicates the number of hydrogen ions contained in a solution that affects biological life within it. The degree of acidity of water should be
neutral, should not be too acidic or too alkaline. The standard quality pH range of about 6-9, the results show that the exhaust pH is in a neutral range indicating safe water is discharged into the environment.

Acidity degree (pH) is an important factor in the water treatment process aimed at improving water quality [19].

From the results of laboratory tests obtained results that the value of suspended substances, BOD, COD, Oil & grease, Ammoniac, Coliform still meets the requirements and deserves to be discharged to the receiving water body. This shows that the quality of processed waste is still in the category of safe and can be reused as raw materials or raw water sources for hospitals. The use of recycling water that has been previously mentioned can be used as agriculture, firefighting, flushing of toilets, industrial cooling, park watering etc. Processed wastewater belongs to the category of grade -3 raw water, this shows that the quality of processed waste is still in the category of safe and can be reused as raw materials or raw water sources for hospitals. Utilization of water that can be done on wastewater processed water products such as to water plants, wash cars or other operational equipment, cooling or washing machines, or absorbed back into the soil as a raw water source for soil. Utilization needs to be re-adjusted to the needs and availability of resources both material, physical and human resources.

3.3. Cleaner Production Analysis

The quality of water processed wastewater treatment shows that processed water can be reused as raw material for water in hospitals. Furthermore, from field analysis and identification of wastewater treatment then carried out an analysis of the causes of inefficiency in wastewater treatment. At the stage of the wastewater treatment process, there are inefficiencies in the use of energy, water and materials (raw materials and auxiliary materials / auxiliary materials). These inefficiencies will affect high operational costs and improve environmental performance due to a large amount of waste produced.

The analysis is then carried out to see and identify the efforts that can be made to improve wastewater treatment performance through the implementation of cleaner production. Therefore, it is necessary to make cleaner production measures that are likely to be implemented onto WWTP. The results of the analysis as well as alternative handling and improvement as an implementation application of cleaner production are displayed in table 4. The main category of the issue divided into 4 category which is human, methods, material and machine.

| No | Category | Main Problem | Implementable clean production options |
|----|----------|--------------|----------------------------------------|
| 1  | Human    | Lack of Human Resources and Training | conducting regular training to improve the quality of human resources |
| 2  | Methods  | Inefficient use of water | Installation of standard operating procedures on each source of waste as well as instructions for use and efforts to save that can be done |
| 3  | Material | The potential of odour and disease in the environment | Replacement of materials or materials in waste treatment and the use of renewable technology in processing |
| 4  | Machine  | Lack of maintenance | making a schedule for checking and routine monitoring of the machine |

4. Conclusion

Wastewater quality results show that the water quality is still above the standard of wastewater quality so that wastewater can be recycled for hospital raw water needs for plant flushing needs, flushing toilets, cooling machines etc. The identification results showed that WWTP at each stage, WWTP occurs with the main inefficiency in four aspects: human, methods, material, and machine. The application of cleaner production is proven to improve the quality of water produced by wastewater treatment by identifying opportunities – opportunities of inefficiency found in wastewater treatment. In each aspect, examine the main problems in it and analyze the implementation of cleaner production
that can improve performance and mechanisms. The efforts can be implemented directly to wastewater treatment management in X hospital.

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