Cleaner production analysis at hospital wastewater treatment plant

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Abstract. The construction of WWTP (Wastewater Treatment Process) 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. The wastewater management strategy used in Hospital X uses an end of pipe strategy that focuses only on sewage treatment and disposal, so as not to completely solve existing environmental problems. Cleaner production analysis is applied to improve wastewater management and WWTP performance thus improving WWTPs operational cost-efficiency. The implementation of cleaner production can be one of the alternatives to reduce management costs through the identification of opportunities also inefficiencies found in WWTP management in hospitals. The analysis was carried out using descriptive analysis through the depiction of the water balance in WWTP treatment, the analysis then continued using fishbone diagrams to see the efficiency opportunities that can be applied. The results showed wastewater produced from the hospital met the standard requirements of wastewater quality so that it can be reused as one of the raw water sources for the hospital's operational activities.

1. Introduction
Hospital wastewater contains chemical compounds as well as pathogenic microorganisms, which can cause disease for it to be required Wastewater Treatment Plant (WWTP) at each hospital that has been contained in Ministry of Environment and Forestry of The Republic of Indonesia Regulation No. 5 2014th about wastewater quality standards. Many problems found in WWTP management are the lack of attention from the hospital management weighing that WWTP management will increase the operational costs of the hospital. Along with the development of environmental awareness and regulation, demands to cut costs associated with public spending on health care have forced hospitals and other entities to improve environmental performance[1]. The implementation of clean production can be one alternative to reduce management costs through the identification of opportunities also inefficiencies that exist in WWTP management in hospitals.

X Hospital located in West Jakarta which is the site of the research, conducted efforts to use liquid wastewater in 2008, but utilization efforts are no longer carried out because of the operational costs of the equipment and the hospital has not done the calculation of WWTP operational costs. Research conducted by [2]at Pucang Sewu Surabaya Public health centreconccluded that wastewater produced from public health centre meets the standard requirements of wastewater quality so that it can be reused as one of the raw water sources. Other research that has been done before [3]implementation of clean production through reuse of water resulted in a 50% savings in water usage costs. The implementation of cleaner production can reduce WWTP management costs through the identification of inefficiencies also opportunities contained in WWTP to be further analyzed economically to see the number of expenses and decreases in operating costs that occur when the implementation of cleaner production is carried out. The final result of the analysis is the cost efficiency options/opportunities for hospital WWTP management costs.
Hospital liquid waste refers to infectious, harmless and hazardous liquid waste with free liquids arising from dental, medical, pharmaceutical or similar practices, teaching and or research that require additional packaging to ensure the safety of transportation, care and storage[4]. Hospital liquid wastewater can contain organic and inorganic materials that are generally measured by BOD, COD, TSS, and other parameters [5]. The realization of sustainable waste management requires a holistic and balanced approach in evaluating management policy strategies [6]. Wastewater management carried out in health care facilities is reviewed from three aspects including the waste type and source, waste characteristics and wastewater treatment system [7].

Cleaner production is defined as an ongoing application of an integral and preventive environmental management strategy to processes, products and services to increase ecoefficiencies and reduce human and environmental risks according to [8]. Clean production implementation technology is a combination of waste reduction techniques on sources and recycling techniques. Environmental management strategies through clean production approaches are carried out to prevent or avoid the formation of waste [9]. Cleaner production therefore focuses on before-the-event techniques that can be categorized including source reduction (Good housekeeping), Process changes (that can be done with better process control, equipment modification, technology change also input material change), Recycling (including on-site recycling, and useful byproducts through off-site recycling) also product modification [10].

Reducing waste at its source is an attempt to reduce the volume, concentration, toxicity, and level of waste hazards that will spread in the environment, preventively directly at the source of polluters. After the effort of minimization of waste is carried out to the maximum, then the waste that is formed is then processed about concerning to the standard quality of waste that applies [11]. Efforts to implement waste minimization several strategies will contribute to waste minimization including

Avoid waste creation (changing the production process, so that less production waste is created, by using cleanliness technologies, methods to improving selectivity, upgrading by-products), Use less material to produce a product (through dematerialization, miniaturization, light-weighting), Create durable/re-usable/repairable products (using measures that postpone the product becoming waste) and use less harmful substances (to an expected hazardous waste flow is replaced with a less dangerous one[12].

2. Materials and methods

Sampling is done by laboratory analysis of wastewater output from WWTP treatment system taken in January 2020. The analysis that was done included components of physics, chemistry and biology parameter which are BOD(Biological Oxygen Demand), COD (Chemical Oxygen Demand), TSS (Total Suspended Solid), and other parameters. Analysis of WWTP processing process conducted through Observing and analyzing the WWTP processing process found in X hospital. WWTP processing process is described into a flow diagram process using descriptive analysis. The results of the WWTP treatment process are then made a balance of water to see the direction of the inflow and outflow of the water contained in the hospital. The analysis obtained is then processed and analyzed using the fishbone diagram to see the inefficiency process that occurs in the processing process and to know the efforts that can be made so that the WWTP processing process becomes more efficient.

3. Results and discussion

3.1. Wastewater Treatment System Water Balance

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 [13]. Wastewater treatment plant (WWTP) in RS X uses a combination of aerobic and anaerobic treatment systems. WWTP is divided into two processing plants namely WWTP I and WWTP II. WWTP I have a capacity of 750 m$^3$/day while WWTP II has a capacity of 100 m$^3$/day. Each treatment system has a
different source of wastewater. The water balance sheet can be seen in figure 1. The water balance shows that the water managed by WWTP comes from several different sources where the incoming water from each unit is not all directly processed into the WWTP machine. In WWTP I Liquid waste comes from all hospital activities derived from toilets, bathrooms, sinks, urinals, laboratory waste (blood/serum/plasma, urine and reaction/reagent remnants) both from service rooms and offices flowed to the container before being put into the processing machine. WWTP I used aeration tubs and sedimentation ponds as a processing process. at WWTP II Special units such as laundry and nutrition through the primary treatment process first before finally being incorporated into the wastewater treatment machine (WWTP). The source of waste derived from nutrition unit, canteen installed grease trap to filter fat before being put into the processing process. WWTP II also uses aerobic and anaerobic systems in the processing process using aeration pools and sedimentation pools.

Figure 1. Wastewater Treatment System Water Balance at X Hospital

To ensure that the quality of treated wastewater meets quality standards, some of the wastewater is channelled into an indicator pond in which there are several types of fish that have high sensitivity to wastewater. Wastewater effluent is carried out by self-monitoring test for BOD, COD, pH, ammonia, TSS and tested every month where the results contained in this study are tests carried out in January 2020. The test was carried out in an accredited laboratory to see the quality of wastewater flowed to the waterways.

3.2. Result of the wastewater treatment system
The results of outlets contained in each WWTP are then carried out laboratory tests using several parameters namely pH, BOD5, COD, TSS, Oil & Grease, Ammonia, 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. Laboratory testing was carried out in January 2020 where samples taken came from the results of the WWTP outlet I and II. The results of laboratory analysis are described in table 1 and 2 below.
Table 1. WWTP I Test Results.

| No | Parameter       | Unit | Quality Standards | Results | Method                          |
|----|-----------------|------|-------------------|---------|---------------------------------|
| 1  | pH (26°)        | -    | SNI 06-6989.11-2004 | 6       |                                 |
| 2  | BOD₅           | mg/L | SNI 6989.72-2009 | 30      |                                 |
| 3  | COD             | mg/L | SNI 06-6989.15-2004 | 100     | UP.IK.21.01.07                  |
| 4  | TSS Oil & grease | mg/L | SNI 6989.10-2011 | 30      | <2 (<1.8)                      |
| 5  | Ammonia        | mg/L | SNI 6989.30-2005 | 10      | <0.01                           |
| 6  | Coliform       | MPN/100mL | SNI 6989.10-2011 | 3.000   | <1.8 APHA Ed. 23rd 9221.B-2017 |
| 7  | Discharge      | L/Person/Day | SNI 06-6989.11-2004 | 100    | -                               |

Table 2. WWTP II Test Results.

| No | Parameter       | Unit | Quality Standards | Results | Method                          |
|----|-----------------|------|-------------------|---------|---------------------------------|
| 1  | pH (26°)        | -    | SNI 06-6989.11-2004 | 7       |                                 |
| 2  | BOD₅           | mg/L | SNI 6989.72-2009 | 30      |                                 |
| 3  | COD             | mg/L | SNI 06-6989.15-2004 | 100     | UP.IK.21.01.07                  |
| 4  | TSS             | mg/L | SNI 6989.10-2011 | 30      | <2 (<1.8)                      |
| 5  | Oil & grease    | mg/L | SNI 6989.10-2011 | 5       | <1.8                           |
| 6  | Ammonia        | mg/L | SNI 6989.30-2005 | 10      | <0.01                           |
| 7  | Coliform       | MPN/100mL | SNI 6989.10-2011 | 3.000   | <1.8 APHA Ed. 23rd 9221.B-2017 |
| 8  | Discharge      | L/Person/Day | SNI 06-6989.11-2004 | 100    | -                               |

The test results show that the quality of wastewater produced in WWTP I and II are still below the standard stipulated quality. Wastewater quality also meets the requirements for reuse as raw water because it is included in the category of water that belongs to that category can be used for fishery and livestock purposes following Government Regulation No. 20 of 1990 on Water Pollution Control. Clean production implementation technology is a combination of waste reduction techniques on sources and recycling techniques. Environmental management strategies through clean production approaches are carried out to prevent or avoid the formation of waste Utilization that can be done on
WWTP processed water products such as to water plants, washing 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.

The depiction of the WWTP processing process shows that there are still several inefficiencies in each aspect involved in the WWTP management process. The aspects are categorized into sections divided into human, methods, materials and machines depicted using fishbone diagrams to find out the root of the problem in each aspect, depicted diagram in figure 2.

Figure 2. Fish-bone diagram

Fishbone diagram image shows the root of the problem contained in the WWTP treatment process in hospital X, from the root of the problem is then set options – options that can be implemented to optimize WWTP performance. The basis of cleaner production implementation as mentioned in the literature is divided into five parts: good housekeeping, material input changes, technological changes, product changes, on-site reuse. In a human aspect the problem is lack of human resources training and supervision, an option that can be taken is to conduct regular training or outreach to all employees to increase understanding of WWTP to improve environmental performance. This training is also included in one of the cleaner production implementations, namely good housekeeping. In the method aspect, the problems found are inefficient use of water and lack of reduction in pollutant sources, Laboratory results show that the WWTP process or machine is still functioning properly, but on each waste source there has not been an SOP (Standard Operating Procedure) is making efforts to save water so that the wastewater entering the WWTP is still not be controlled. This can be overcome by installing SOPs at each point of the source of waste. Clean production implementation technology is a combination of waste reduction techniques on sources and recycling techniques. By reducing the source of waste at the source by installing SOPs at each point of the source of waste, it can reduce the quantity of incoming wastewater, so that the process at the WWTP machine can function optimally so that water quality improvement can occur so that water sources can be recycled.

In the material aspect, the problems encountered are pollution due to wastewater and the potential of odour and disease in the environment. Currently, the condition of the engine is still in good condition but if the capacity and hospital patients continue to increase it will decrease engine performance and bring out the possibility of odours and environmental problems. Options that can be taken are the selection of new technology or technology updates contained in the WWTP system. The
choice of new technology will increase the opportunities for reuse of water treatment or recycling results.

In the engine aspect, it is found that lack of maintenance and capacity and engine lifetime, an option that can be done is conducting regular inspection and maintenance of the machine. Existing field operators also have not yet held special training on efforts to conserve water, and machine checks are only carried out if there is a machine leak and there is no fixed machine control schedule. The realization of sustainable waste management through the application of cleaner production demands a holistic and balanced approach in evaluating management policy strategies. This is reinforced by collaborating problem findings in every aspect as well as in implementing options that can be done to improve WWTP management, which is not only done by one party but requires collaboration from everyone considering all aspects are involved in the effort to implement this cleaner production.

4. Conclusion
The results of WWTP treatment show that the water produced from the treatment system is still well categorized and can be reused processed against the water treatment results. Aspects in WWTP management that still need to be improved to advance the WWTP including human, method, machine and WWTP material. Cleaner production might be a tool to find the inefficiencies of a process through identification directly from the sourceso that the implications are not only seen from the main process but from the beginning to the end of the whole process. The implementation or improvement of the options that have been obtained through the cleaner production process if the option implemented properly and consistently, not only to improve the performance of the WWTP but also can become a new energy source for the hospital through reuse of wastewater. The water that obtains from the reuse of wastewater can also reduce the operational costs of clean water requirements in hospitals.

References
[1] Karlsson M and Öhman D P 2005 Material consumption in the healthcare sector: Strategies to reduce its impact on climate change - The case of Region Scania in South Sweden J. Clean. Prod. 13 1071–81
[2] Kholif M Al and Asmoro P 2016 Penerapan Produksi Bersih Sebagai Strategi Penghematan Penggunaan Air Bersih di Puskesmas Pucang Sewu Surabaya J. Tek. WAKTU 14 56–62
[3] Imamuddin M 2016 Re-Use Air Pada Instalasi Pengolahan Air Limbah (Ipal) Guna Mengurangi Daya Rusak Air Di Upt Puskesmas Rawat Inap Ajibata Sumatera Utara J. Konstr. 7 83–94
[4] Journal B, Vol E S, Centre E and Uk D 2016 2,3* , 4 11–34
[5] Rahmat B and Mallongi A 2018 Studi Karakteristik Dan Kualitas BOD Dan COD Limbah Cair Rumah Sakit Umum Daerah Lanto DG. Pasewang Kabupaten Jeneponto J. Nas. Ilmu Kesehat. 1 1–16
[6] Donde O O 2017 Wastewater Management Techniques: A Review of Advancement on the Appropriate Wastewater Treatment Principles for Sustainability Environ. Manag. Sustain. Dev. 6 40
[7] Siregar sakti a 2008 Instalasi Pengolahan Air Limbah Seri Sanitasi Lingkung. Pedoman Tek. Dengan Sist. Biofilter Anaerob Aerob Pengolah. Air Limbah Instal. Pada Fasilitas Pelayanan Kesehat. Kementeri. 24 1–9
[8] Sulaeman 2005 Kajian Produksi Bersih Untuk Industri Batik 23–7
[9] Sumadi - and Hermanadui D 2017 Penerapan Teknologi Produksi Bersih (Cleaner Production) Untuk Peningkatan Produktivitas Dan Kualitas Kacang Oven Pada Agroindustri “Ud. Rajawali” Kabupaten Jember J-Dinamika
[10] EL-Haggar S M 2007 Sustainable Development and Environmental Reform Sustain. Ind. Des. Waste Manag. 125–48
[11] Cara D and Kembali P 2000 Bahan dan Peralatan yang Digunakan
[12] Pongrácz E, Phillips P S and Keiski R L 2004 From waste minimization to resources use
optimization: Definitions and legislative background Proc. Waste minimization Resour. use Optim. Conf. June 10th 942–51

[13] Machdar I, Sekiguchi Y, Sumino H, Ohashi A and Harada H 2000 Combination of a UASB reactor and a curtain type DHS (downflow hanging sponge) reactor as a cost-effective sewage treatment system for developing countries Water Sci. Technol.42 83–8