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Utilization of Wastewater from Air Conditioner Circulation Systems for Clean Water-Energy Efficiency and Industrial Equipment Maintenance

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A B S T R A C T

There is significant wasteful use of clean water for operating equipment during field and laboratory practice. Additionally, damage to laboratory equipment has been reported due to the use of untreated water. These issues, along with previous research on managing air conditioner (AC) wastewater at the Lampung State Polytechnic, form the basis for our initiative to utilize AC wastewater as a sustainable resource. Proper management of this abundant water source can support the operation and maintenance of laboratory equipment. The research findings demonstrate that circulating AC wastewater to operate a Soxhlet extraction system for 4.5 hours can reduce clean water consumption by 0.65 cubic meters, equivalent to a cost savings of IDR 43,200. Furthermore, the results indicate improved efficiency, effectiveness, and overall equipment performance when using AC wastewater compared to conventional methods.

Contribution to Sustainable Development Goals (SDGs)

SDG 6 – Clean Water and Sanitation
SDG 9 – Industry, Innovation, and Infrastructure:
SDG 12 - Responsible Consumption and Production
SDG 13 - Climate Action

1. INTRODUCTION

1.1. Research Background

Implementation of the learning process, which in this case includes practicums in laboratories, often involves wasteful practices in the use of clean water, including the operation of laboratory equipment that requires water as a heat-producing medium as well as a cooling medium, namely tools for distillation (distillation) and extraction tools. The working principle of this equipment is to heat the water in the heating chamber. Then, the hot steam is channeled into the extraction and distillation chamber, which is connected to a cooling pipe that flows with water so that the extraction or distillation process runs well. The water in this cooling pipe must flow at a certain speed, and it doesn't stop until the distillation/extraction process is complete, thus requiring continuous flowing water during the process, which lasts around 3 to 4 hours. From the reading of the water flow speed indicator (flow water meter display) on one of the distillation tools in the Politeknik Negeri Lampung Agricultural Products Technology Laboratory, information was obtained that when the tool was operated, the water flow speed used was 2.4 liters/minute, so that if the tool was operated for 4 hours consumes 576 liters of water. Then, the water from the cooling pipe is not used for other purposes, so it is wasted.

Besides the cooling process, clean water in laboratory equipment is also used as a heat-producing medium with a water heater. There are often cases of damage to laboratory equipment because the water used contains inorganic compounds that settle and form crystal deposits. Crusting occurs on the surface of the heating pipe, the heating chamber and plate, or the hot water pipe, as well as moss growth and deposition. Cooling pipes marked with a dark brown color on pipes made of glass material, resulting in compression of the pipe and causing interference with the tool's performance, ultimately leading to reduced efficiency and effectiveness of the tool's work. Utilization of wastewater from air conditioning (AC) circulation systems It is necessary to calculate the efficiency of saving clean water and analyze the maintenance and operation of equipment so that it is hoped that it can reduce the possibility of equipment damage.

1.2. Literature Review

Clean water is a basic human need that directly impacts society's physical, social, and economic well-being. Continuous use of groundwater in large quantities results in a decrease in groundwater reserves. Additionally, groundwater quality is decreasing due to seawater intrusion and household wastewater pollution [1]. Even though water is a renewable resource, clean water is non-renewable. Clean water scarcity is a situation with a water shortage to meet human needs. A country is said to be experiencing water stress when the annual water supply is less than 1,700 m3 per person. Then, if the annual water supply is less than 1,000 m^3 per person, the country is said to be experiencing a water scare [2]. If it is calculated that almost 2 billion people currently experience water shortages, then with the addition of another 1 billion people, it is estimated that clean water will be scarce by 2025.

The energy crisis facing humans worldwide today, including Indonesia, cannot be ignored. Energy reserves in Indonesia are shrinking day by day. This is also exacerbated by waste in its use [3]. Along with the increasing population, which reached 281,603,800 people [4], energy availability, including clean water, is increasingly scarce. On the other hand, clean water is often used excessively and even tends to be wasted. Water is a form of energy that can be used sparingly. Water is a natural resource that can be renewed. Still, along with population growth and very rapid urban development, water availability is starting to decline in quantity and quality. Wasteful behavior of clean water causes more and more people to lose access to clean water. You can save water in many ways, including limiting water use [3].

The rapid growth in the number of industries and offices currently results in the need for and use of water increasing every year. The government is also trying to reduce water consumption in government buildings and offices. One of the efforts to avoid clean water scarcity is to save on using clean water and conserve water resources [1]. In recent years, several parties have widely promoted efforts and measures to save water, both personal and organizational. As a result, there are currently many movements to love and care for nature, one of which is to preserve and save water supplies. However, if we look carefully at several government agencies, we generally still find wasteful practices in using clean water, and we often find leaking taps in several office bathrooms, ablution areas, and toilets and sinks in several laboratories. Running water is wasted [5].

1.3. Research Objective

This research aims to determine how much clean water efficiency can be saved and whether using AC wastewater for equipment maintenance and operation can reduce the possibility of equipment damage.

2. MATERIALS AND METHODS

The materials used in this study include a soxhlet, autoclave, water pump, thermometer, stopwatch, and water flow meter. The materials used in this study include a reservoir, hose, caustic soda, potassium chromate distilled water, air conditioning (AC) wastewater, and cool pack. The research design consists of cleaning the cooling channels/pipes and heating plates, installing a circuit for circulating cooling water, and operating the equipment with wastewater from the AC circulation system.

The first step in the research process is to clean the cooling pipe (condenser) in the soxhlet device on the inside through which the cooling water flows and the heating device made of steel plate by soaking the glass pipe of the cooling channel with a 1.5% NaOH solution for 12 hours. The layer of moss and dirt that has settled on the surface of the pipe is lifted and then rinsed with clean water until the tool is clean at the stage of installing the circuit for circulating cooling water. The storage tank is made of fiber with a capacity of 80 liters; a water pump with the specification Kandila 2200 Z, 1500 l/h, 15 W, 1.8 M is installed to drain the water into the cooling pipe; a thermometer to control the temperature of the water used; and a plastic hose is installed, which is elastic and allows cooling water to flow. Some of the flowing water is used as a steam feeder to be heated and as a producer of heat energy. Next, an elastic-plastic hose is connected to the drain pipe from the cooler so that the water used for the cooling process flows back from the cooling pipe to the reservoir.

The next stage is operating the tool with an AC wastewater circulation system. The device is connected correctly and adequately after ensuring that the cooling pipe and heating chamber are clean. The tub is filled with 60 liters of AC wastewater, and then the water pump is turned on so that the water is forced to flow into the hose leading to the cooling chamber (condenser) until it flows. Please return it to the reservoir and ensure there is no leak. The experiment in this research was designed to obtain data regarding the amount of AC waste water used during the extraction process, the impact of using AC waste water on cooling pipes, and the impact of using AC waste water on the heating plate (heater) and heating room (steam). The circulation system AC wastewater utilization scheme is shown in Fig.1.

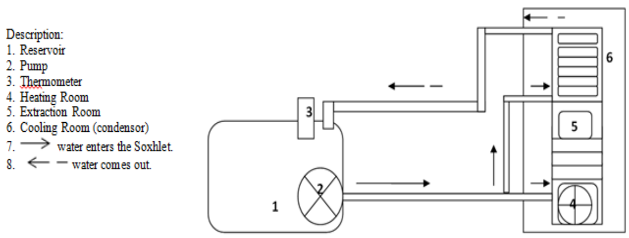

Fig.1. Scheme for the utilization of wastewater from air conditioning systems for extraction tools (Soxhlet).

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To obtain data regarding the amount of AC waste water used during extraction. The device (soxhlet) is turned on for the extraction experiment for 4 hours, and the thermometer is periodically checked to indicate the water temperature. Suppose there is an increase in the water temperature. In that case, the effort to stabilize the water temperature is by inserting a cool pack into the water bath so that the temperature is stable according to room temperature. After the extraction experiment was completed, the soxhlet was turned off. Then, measurements of the AC waste water were used to obtain data on the reduction (shrinkage) of water used to heat the heating room (steam). This experiment was carried out several times for the extraction process. The impact of using AC waste water on cooling pipes. The device (soxhlet) was turned on for the extraction experiment for 4 hours. After the extraction process was complete, the soxhlet and water pump were turned off, but it was ensured that the water in the cooling pipe did not come out (still soaking) the cooling pipe. This experiment was carried out several times for the extraction process. The impact of using AC waste water on the heating plate (heater) and heating room (steam). The device (soxhlet) was turned on for the extraction experiment for 3 or 4 hours. After the extraction process was complete, the soxhlet and water pump were turned off, but it was ensured that the water in the heating chamber (steam) did not come out (still soaking) the heating plate (heater). This experiment was carried out with several repetitions for the extraction process..

3. RESULT AND DISCUSSION

3.1. The process of occurrence of Air Conditioning wastewater

Air conditioning wastewater results from the cooled room's air condensation process. When the AC is turned on, it will produce liquid waste in clear water, which flows through the drain pipe [6]. AC wastewater results from condensation and has almost the same physical and chemical properties as distilled water. The water from the AC results from pure condensation and can most likely be used. AC wastewater can be used as a substitute for distilled water based on the similar properties between AC water and purified water. Aquades is the result of pure distilled water and does not contain metals or anions and has a pH of 7 or neutral, while water from AC or AC waste does not contain cations or anions and has a pH of 7 or neutral [7].

3.2. Extraction trial process with 4 hours

The extraction trial process took 4 hours. During the first hour of the trial, the temperature was still relatively stable, namely ranging between 26-28 °C [8], following what is required in the 2010 Minister of Health Regulation that the requirements for clean water quality are a temperature ranging between 25-29 °C [8], but after more than 2 hours the water temperature in the holding tank increased several degrees (range 30-32 °C). This was caused by the water flowing in the cooling pipe above the extraction flask in contact with hot air from the solvent vapor, so the longer it is in contact with hot steam, the more the water temperature increases. Because the function of AC waste water here is not only as a steam feeder but also as a coolant [9] so that the cooling runs well and efficiently, the water temperature must be kept stable. In carrying out this trial, we applied it by opening the reservoir cover. The end of the hose that drains the water entering the tub is slightly lifted upwards so that when the water flows into the tub, there is a flow process (like a shower), which results in the entry of oxygen into the water. Thus, the process of cooling the water will occur due to the oxygen entering the water, inhibiting the rate of increase in cooling water temperature. Next, the water in the reservoir will be sucked up again by the water pump and then flow back into the cooling pipe section of the soxhlet (circulation occurs) so that no water is wasted.

The following data was obtained from the observations: The condition of the AC wastewater used during the extraction trial process was clear/no clouding, and the amount was 60 liters. The cooling pipe on the Soxhlet device looks clean without growing moss or dirt deposits. The heating chamber and plate are clean, with no deposits, sticks, or crust deposits.

3.3. Measurement of clean water use in trials using the Soxhlet extraction tool

In the extraction process, cooling is required to distill the extraction solution. The cooling is carried out by flowing clean water through the cooling pipe. Water flow is needed for a certain speed to obtain an optimum cooling system. In this study, the recorded water flow speed was 2.4. liters per minute; thus, if the tool is operated for the extraction process for 4 hours and waits until the tool cools after being turned off, an additional 0.5 hours is needed. If calculated (2.4 x 60) x 4.5 = 648, then using clean water as a coolant with the operation for 4.5 hours will consume 648 liters of water, or the same as 0.648 cubic meters. Information on the price of clean water in Bandar Lampung in 2024 per cubic meter is Rp. 66,700; the cost of 0.648 cubic meters is the same as Rp. 43,200. Thus, this method can save as much as 648 liters of clean water if converted into a monetary value equivalent to Rp. 43,200.

A water pump with 15 watts of power is used to circulate the cooling water. If the water pump is turned on for 4.5 hours, the electrical power is (15 watts x 4.5 hours = 67.5 watts, or the equivalent of 0.0675 KwH). If each KwH costs Rp. 1,467, then for 0.0675 KwH, it is IDR. 99.02,-. The calculation of operational cost savings is the total cost savings for using clean water minus the total electricity costs for using a water pump (43,200 - 99 = 43,101), so the total operational cost savings is Rp. 43,101.

3.4. Observation of the cooling pipe on the Soxhlet apparatus

The cooling pipe in the Soxhlet tool is made of glass, which forms a spiral circle in the glass tube, with a spiral diameter of around 5 cm, a cooling glass tube diameter of around 5 mm, and a pipe hole diameter of around 2.5 mm. With the condition of the spiral pipe being so complicated, it can Be categorized that this cooling pipe is a tool that is very vulnerable to breaking, gets dirty quickly, and is difficult to clean, so it needs special attention in its operation and maintenance. For this reason, it is necessary to use clean water with relatively minimal sedimentation and moss growth. Using AC wastewater during the testing process until several months after the testing, the cooling pipes still look clean; there is no growth of moss or sediment attached to the surface of the pipes.

3.5. Observation of the heating chamber in the Soxhlet apparatus

The heating chamber in the Soxhlet apparatus is a place to produce hot steam, which is then channeled to heat the fat cup so that the solvent evaporates. In the heating chamber, there is a pair of heating plates (heater); when filled with water, this pair of electric plates is used for the heating process. If the water used for heating contains minerals, crusting will occur on the surface of the plate, and the longer the buildup occurs, the longer it will interfere with the tool's performance. In trials using AC wastewater, the heating chamber and heating plate appeared to remain clean, with no signs of rust and no deposits appearing.

4. CONCLUSION

Utilizing Air Conditioner wastewater using the circulation method to operate equipment in 4.5 hours can save 648 liters of clean water usage and operational costs of IDR 43,101. This finding shows better efficiency, effectiveness, and equipment performance.

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