PERFORMANCE OF DAIRY FACTORY WASTEWATER TREATMENT PLANT (CASE STUDY OF PASURUAN DAIRY FACTORY EAST JAVA)

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Abstract

The 'ILP' company produces bottled milk with chocolate, melon, strawberry, and vanilla flavors in colorless HDPE (High-Density Polyethylene) plastic bottles and aluminum foil covers. The 'ILP' dairy industry wastewater treatment process stages include bar screen, grease trap, equalization tank, flocculation-coagulation, primary clarifier, aeration tank/activated sludge, and secondary clarifier. The research aims to determine the performance of the dairy factory's WWTP (Wastewater Treatment Plant) in terms of TSS (Total Suspended Solids) and COD (Chemical Oxygen Demand) parameters. This field-scale research was carried out for approximately 5 weeks (35 days) at the wastewater treatment plant of the ILP company. Wastewater sampling is carried out at the inlet point, equalization tank, primary sedimentation, aeration tank, and outlet point of WWTP. Wastewater examination conducted in the company's internal laboratory, including temperature, pH, total suspended solids (TSS), and chemical oxygen demand (COD). The dairy factory WWTP (wastewater treatment plant) can generate TSS (total suspended solids) effluent of 22 mg/L and COD (chemical oxygen demand) of 26.8 mg/L to meet the applicable wastewater quality standards. The treatment efficiency of the dairy industry WWTP for TSS is 94.7% and COD is 98.1%.

Keywords: *COD, TSS, wastewater treatment plant, bottled milk industry*

Introduction

East Java, Central Java, and West Java Provinces were the main production zones of milk producers. East Java Province accounted for 54.2 percent of the total national milk production, followed by West Java with 33 percent contribution and Central Java with 10.8 percent (Wijayanti et al., 2023). The consumption of milk per capita in Indonesia was lower compared to other Southeast Asian countries, e.g., Malaysia (36.20 kg/capita/year), Myanmar (26.7 kg/capita/year), and Thailand (22.2 kg/capita/year). Indonesia is one of the countries with the highest milk deficit along with China, Italy, Russia, Mexico, and Algiers. Even though, the average growth of whole milk consumption in Indonesia from 2017-2020 has increased by 1.23% per year (Daryanto et al., 2021), (Prasetyani & Suryono, 2023).

By definition, the milk processing industry is an industry that produces basic milk and processes it to the pasteurization stage or processes it in an integrated manner to produce liquid milk, cream, condensed milk, powdered milk, cheese, butter, and or ice cream The dairy industry processes milk into several products, including liquids milk, powdered milk, yogurt, cheese, butter, ice cream, with different processes, it will discharge wastewater with different characteristics. The volume of dairy industry wastewater is quite

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large, about 0.2-10 liters per liter of processed milk, (Mohebi-Fard et al., 2015), (Adi Rohmanna et al., 2021).

Most of the liquid waste of the dairy industry comes from the production process, i.e. from spillage during transfer/filling or, the process of spoiled/rejected milk that does not meet the standard. Dairy industry effluent is white, slightly alkaline, and contains carbohydrates, proteins, suspended solids, fatty oils, nitrogen, phosphates, and lactic acid. Dairy industry wastewater contains high organic content and is easily decomposed, so BOD5 and COD values tend to be high, and cause unpleasant odors from the decomposition process, (Mohebi-Fard et al., 2015), (Adi Rohmanna et al., 2021), (Prasetyani & Suryono, 2023). The characteristics of dairy industry wastewater have a suspended solids content of 350-1,500 mg/L, a pH value between 4-12, a BOD5 value of around 3,000 mg/L, a COD value of around 5,000 mg/L, ammonia nitrogen of 20-60 mg/L, fat of 350-700 mg/L (Vasina & Basamykina, 2022). Parameters in dairy industry wastewater quality standards include pH between 6-9, BOD5 at 40 mg/L, COD at 100 mg/L, TSS at 50 mg/L, oil and fat at 10 mg/L, NH3-N with a value of 10 mg/L (Anonim, 2014).

Dairy industry wastewater treatment methods are generally biological and physico-chemical. Biological treatment can be done aerobically, where activated sludge is one of them, anaerobically and constructed wetlands. The physicochemical methods commonly used are coagulation and flocculation (Bella & Rao, 2023). Conventional treatment of dairy industry wastewater includes precipitation, coagulation-flocculation, adsorption/filtration, and biodegradation. In recent years, the membrane separation technology (MST) treatment method has become an option for the dairy industry wastewater treatment. Dairy industry wastewater treatment with membrane processes has several advantages including reduced process steps, minimal impact on product quality, operational flexibility, and lower energy consumption (Al-Tayawi et al., 2023). Dairy Industry Wastewater Treatment shows potential environmental impacts, namely human health impacts of 1.27 x 10-3 and ecosystems of 3.94 x 10-6 based on analysis using the Life Cycle Assessment (LCA) method (Wijayanti et al., 2023).

The 'ILP' company is located in Pasuruan, East Java at an altitude of 832 meters above sea level with an average temperature of 27°C. Company 'ILP' is a company that produces liquid milk drinks with chocolate, melon, strawberry, and vanilla flavors in colorless HDPE (High-Density Polyethylene) plastic bottles and aluminum foil covers. Raw materials are fresh milk with additional ingredients Skim Milk Powder (SMP), sugar, vanilla, chocolate, melon, and strawberry flavors, color, vitamins, stabilizers, and water. The 'ILP' company requires fresh milk raw materials of around 40 tons to 50 tons per day, with a production capacity of 17,000 to 18,000 boxes, each box contains 24 milk bottles containing 190 ml of milk. The production process lasts for 24 hours, so the workforce is divided into 3 work shifts, namely the morning shift (06.30 - 15.00), afternoon shift (14.30 - 23.00), and night shift (22.30 - 07.00).

The SHE (Safety, Health, and Environment) and WWTP departments was responsible for maintaining the safety and health of employees inside and outside the production process room and wastewater treatment to achieve zero emissions. 'ILP' industrial wastewater comes from the production process, product rejects, offices, toilets, and kitchens; and flows to the wastewater treatment plant. The wastewater treatment plant (WWTP) is located in an area of 400 m2. The stages of wastewater treatment in WWTP are: bar screen, grease trap, equalization tank, flocculation coagulation, primary clarifier, aeration tank / activated sludge, secondary

clarifier, control tub, effluent then flowed into the nearest river. the sludge from the primary sedimentation and secondary clarifier flowed to the sludge thickener, belt thickener, and finally the sludge drying bed. WWTP effluent monitoring was carried out regularly through routine sampling for laboratory examination.

Research Methodology

The research aims to determine the performance of the dairy factory's WWTP (Wastewater Treatment Plant) in terms of TSS (Total Suspended Solids) and COD (Chemical Oxygen Demand) parameters. This field-scale research was carried out for approximately 5 weeks (35 days) at the wastewater treatment plant of the ILP company. Measurement of wastewater discharge is carried out every day at the WWTP inlet. Wastewater sampling is carried out at the inlet point, equalization tank, primary sedimentation, aeration tank, and outlet point. Wastewater examination is carried out in the company's internal laboratory, including of temperature, pH, total suspended solids (TSS), and chemical oxygen demand (COD). The wastewater discharge from the dairy factory was measured at the wastewater treatment plant's inlet (WWTP). Temperature and pH parameters were measured daily at the inlet WWTP, equalization tank, primary clarifier, aeration tank, and WWTP outlet. TSS and COD parameters were measured daily at the inlet WWTP, equalization tank, primary clarifier, aeration tank/activated sludge, and effluent WWTP.

Result and Discussion

WWTP wastewater discharge measured over 35 days showed fluctuations, with an average value of 96.9 m^3/day. If correlated with milk production, every 1 liter produced produces about 1.18 liters of wastewater.

Previous research shows that every liter of pasteurized milk produces 2.5 liters of wastewater (Mohebi-Fard et al., 2015), and it is estimated that the volume of wastewater produced is 50% to 80% of the clean water used (Adi Rohmanna et al., 2021).

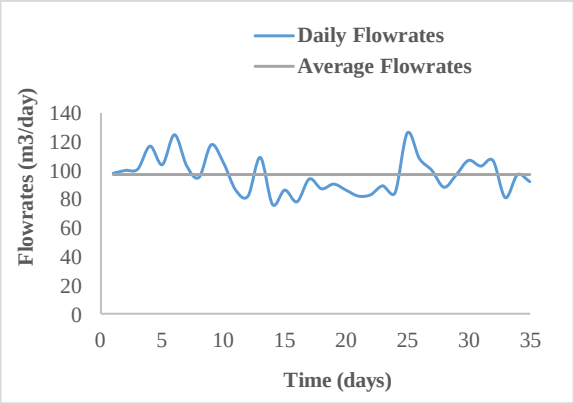

Figure 1. Wastewater flow rate fluctuation.

The dairy factory wastewater treatment plant is carried out in stages and consists of a physicochemical process, followed by aerobic treatment. Chemical physical treatment processes in WWTP include the bar screen, grease trap, equalization tank, flocculation coagulation, and primary clarifier; meanwhile, aerobic biological treatments consist of an aeration tank/ activated sludge unit, and secondary clarifier.

The results of pH and temperature measurements daily at the inlet WWTP, equalization tank, primary clarifier, aeration tank, and outlet WWTP are calculated for the average value, and presented in table 1, below.

Table 1. Temperature and pH value in WWTP.

Parameters	Inlet WWTP	Equali-zation tank	Primary clarifier	Aeration tank	Outlet WWTP
Temperature (°C)	31.3	30.6	30.2	29.7	29.2
pH	7.6	7.6	7.4	7.7	7.8

The average temperature value in the influent WWTP is the highest, at 31.3 °C, while in the equalization tank at 30.6°C, the primary clarifier

at 30.2 °C, in the aeration tank at 29.7 °C, in the effluent WWTP at 29.2 °C. While the pH value in WWTP does not fluctuate, in WWTP influent, it is 7.57, equalization tank 7.57, in the primary clarifier 7.41, in the aeration tank 7.68, in WWTP effluent 7.75.

The values of TSS and COD decrease in the WWTP after progressing through the stages of physical-chemical treatment and aerobic biological treatment. Both parameters show a reduction from the inlet, through the equalization tank and primary clarifier, to the WWTP outlet. The most significant decrease in TSS and COD occurs between the primary clarifier and the outlet WWTP.

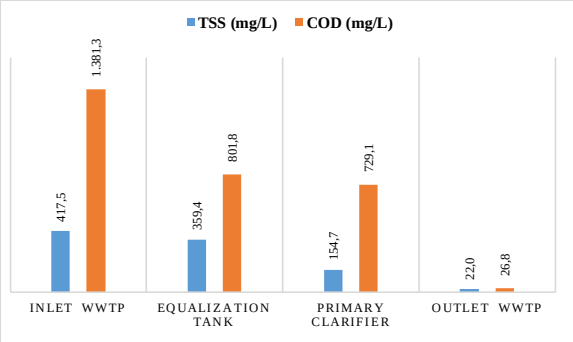

Figure 2. TSS and COD parameters in dairy industry WWTP.

The calculation of TSS and COD removal is presented in Table 2. WWTP effluent from the dairy industry has met the applicable wastewater quality standards. The TSS value in the quality standard is 50 mg/L and the WWT effluent TSS is 22 mg/L. The COD effluent value of 26.8 mg/L is already below the wastewater quality standard; that is 100 mg/L.

The TSS removal value from the inlet to the equalization tank is 13.9%. This removal occurs by the role of a barscreen unit and grease trap to reduce the value of TSS. The removal efficiency measured in the primary clarifier increased considerably to 62.9%, an enhanced efficiency of 49% which may result from the coagulation-flocculation and sedimentation process.

Biological treatment in the form of activated sludge proved effective in reducing TSS by 31.8%. A suspended solid in dairy industry wastewater is a biodegradable suspended solid that degraded easily by microorganisms in the activated sludge process. At the outlet of the WWTP TSS measured at 22 mg/L, there is a total removal of the entire WWTP process of 94.7% compared to the TSS value at the WWTP inlet.

Table 2. TSS and COD removal in WWTP.

Unit Treatment	TSS (mg/L)		COD (mg/L)	
	average (mg/L)	efficiency (%)	average (mg/L)	efficiency (%)
Inlet WWTP	417.5		1,381.3	
Bar screen with grease trap				
Equalization tank	359.4	13.9	801.8	42.0
Coagulation Flocculation				
Primary clarifier	154.7	62.9	729.1	47.2
Aeration tank/ Activated sludge				
Secondary clarifier				
Outlet WWTP	22.0	94.7	26.8	98.1

The effluent of the bar screen, grease trap, and equalization tank treatments were able to produce a COD removal of 42%. This is related to the removal of oil, fats, and suspended solids carried in the wastewater by the bar screen, grease trap, and equalization tank. Coagulation-flocculation and primary clarifier treatment were able to improve COD removal by 5.3%. The largest COD removal occurred at the activated sludge and secondary clarifier treatment stages, which amounted to 50.8%. Dairy industry wastewater contains a lot of organic material that is easily decomposed, and the activated sludge process is proven to be effective in removing organic matter in dairy industry wastewater. The total COD removal efficiency

in the dairy industry WWTP is 98.1%, resulting in a COD value of 26.8 mg/L below the wastewater quality standard of 100 mg/L. The dairy factory WWTP has performed well, with TSS efficiency of 94.7% and COD efficiency of 98.1%, resulting in effluent that meets applicable effluent quality standards.

Dairy factory wastewater contains organic matters that are easily decomposed, resulting in high treatment efficiencies above 90%, for TSS, BOD, and COD parameters (Savira & Zamrudy, 2023), (Al-Tayawi et al., 2023).

The drawback of this study is that it cannot analyze BOD and fatty oil because the dairy industry's laboratory does not have the equipment to analyze BOD and fatty oil in wastewater. The wastewater quality has to measured at each inlet and outlet process stage needs to be done, to determine the performance of each stage of the treatment process so that the treatment process can be evaluated.

Conclusions

The 'ILP' dairy industry wastewater treatment stages include bar screen, grease trap, equalization tank, flocculation coagulation, primary clarifier, aeration tank / activated sludge, and secondary clarifier. The dairy industry WWTP can produce TSS effluent of 22 mg/L and COD 26.8 mg/L meeting the applicable wastewater quality standards. The treatment efficiency of the dairy industry WWTP for TSS is 94.7% and COD is 98.1%.

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