Sustainable Agriculture Research Journal (SAR JOURNAL)

e-ISSN: 3109-3825
https://e-journal.tematikapertanusantara.sch.id/index.php/SAR-Journal
Vol.1 (No.2): 77-85, 2025

Analysis of Wastewater Quality in a Cow's Milk Processing Industry at CV PQR

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ABSTRACT

CV PQR is a dairy processing company that produces pasteurized milk and yogurt. Daily production activities generate both solid and liquid waste. Therefore, an evaluation of the wastewater treatment process is required, along with testing of wastewater quality parameters to assess compliance with environmental quality standards. The wastewater treatment process was directly observed and consists of several stages, including initial holding, bacterial incubation, equalization, aeration I and II, flotation, sedimentation, mediation, koi fish bioassay testing, and sludge recirculation. Data collection was conducted during an internship period from 24 February to 24 March 2025. Laboratory analyses were performed for several parameters, namely total suspended solids (TSS), pH, chemical oxygen demand (COD), biochemical oxygen demand (BOD), oil and grease, ammonia, and total coliform. The results indicate that most wastewater quality parameters complied with the applicable discharge standards stipulated in the Regulation of the Minister of Environment of the Republic of Indonesia No. 5 of 2014, including TSS, pH, BOD, oil and grease, and ammonia. However, non-compliance was observed for COD in July and August, as well as for total coliform in most months, except in October. These findings suggest that although the wastewater treatment system has been generally well implemented, further improvements and stricter monitoring are required, particularly in controlling pathogenic microorganisms. Overall, the wastewater treatment plant (WWTP) at CV PQR has been functioning relatively effectively; however, periodic evaluations remain necessary to ensure that the effluent does not cause environmental pollution.

Keywords: *Pasteurized milk, quality standards, wastewater*

Introduction

CV PQR is a company engaged in the production and commercialization of pasteurized milk products. Pasteurization is a milk processing method that involves heating at lower temperatures than sterilization, typically below the boiling point of water, such as at approximately 73 °C for 30 minutes or 92 °C for 15 seconds. This method is classified as mild heat treatment aimed at eliminating most pathogenic microorganisms while preserving the nutritional content of milk. The primary raw material used at CV PQR is fresh cow's milk. Milk is considered a highly nutritious food, as it contains proteins, essential fatty acids, vitamins, and minerals (Claeys et al., 2014). Fresh cow's milk at CV PQR is sourced from several nearby dairy farmer cooperatives (KUDs). CV PQR's pasteurized milk products are available in two types of packaging, namely cup packaging (regular cups and industrial cups) and minipacks. The regular cup products are available in chocolate, strawberry, vanilla, mocha, biscuit, and orange flavors, while the industrial cup products are available in chocolate, strawberry, and mocha flavors. Minipack products are available in chocolate, strawberry, sweet plain milk (SPM), and pure pack

e-ISSN: 3109-3825
https://e-journal.tematikapertanusantara.sch.id/index.php/SAR-Journal
Vol.1 (No.2): 77-85, 2025

variants. In addition, CV PQR produces yogurt in two packaging types, namely bottles (lychee, plain, and strawberry flavors) and cups (mango, strawberry, and grape flavors). During the yogurt fermentation process, changes occur in the composition of nutrients such as carbohydrates, proteins, fats, and other organic compounds, which are broken down by enzymes produced by specific microorganisms (Yarza et al., 2020).

The manufacturing process produces residual materials commonly referred to as waste. Based on Government Regulation No. 18 of 1999 and Government Regulation No. 85 of 1999, waste is defined as the remaining material generated from human activities. At CV PQR, waste generation can be classified into two categories: solid and liquid waste. Solid waste comprises damaged packaging materials, cardboard, and plastics, whereas liquid waste includes by-products from production operations, such as milk spills, wastewater from the cleaning of machinery, laboratory instruments, and crates, as well as oil residues. Solid waste and oil are not processed directly by CV PQR but are instead handled by authorized third-party waste management services. The primary purpose of wastewater treatment is to remove or reduce dissolved and suspended solids, as these materials may cause damage and hinder the efficiency of subsequent treatment processes (Nurika & Suharti, 2018).

CV PQR is equipped with its own wastewater treatment facility, enabling independent and more efficient waste management. The treatment process consists of several stages. Initially, wastewater enters an equalization tank, which functions to reduce and regulate fluctuations in wastewater flow and to neutralize acidic pH to approximately 6–7 (Ningrum, 2018). During the equalization process, incubated bacteria are added to the tank, including Aerobacter sp., Nitrobacter sp., Nitrosomonas sp., Lactobacillus sp., and Saccharomyces sp. Subsequently, the first aeration process serves to remove dissolved gases and reduce ammonia content in the wastewater (Febriana, 2017). This is followed by a flotation process, which reduces particles such as oil and grease through flotation mechanisms, then a second aeration stage. The next stage is sedimentation, which consists of two sedimentation tanks and functions to reduce the load on the mediation process (Suparmin, 2019). The mediation tank acts as the final holding unit before the treated wastewater is tested using koi fish as a bioindicator. Koi fish are used due to their relatively low tolerance to poor water conditions, such as low dissolved oxygen levels or high pollutant concentrations. Significant changes in water quality may cause koi fish to exhibit stress symptoms or mortality; therefore, the condition of the fish can provide an indication of wastewater quality (Kursini, 2015).

Materials and Methods

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Vol.1 (No.2): 77-85, 2025

Materials

The materials used for the analyses included oxygen-free dilution water supplemented with nutrient solutions (phosphate buffer, $MgSO_4$, $CaCl_2$, and $FeCl_3$), microbial seed/inoculum, Winkler reagents, standard $K_2Cr_2O_7$ solution, concentrated H_2SO_4 with Ag_2SO_4, $HgSO_4$, ferrous ammonium sulfate (FAS) solution, ferroin indicator, preconditioned GF/C filter papers, solids-free water, Nessler reagent, alkaline buffer solution, ammonia standard solutions, petroleum ether or n-hexane, anhydrous Na_2SO_4, solvent blanks, microbiological media (Lactose Broth, Lauryl Tryptose Broth, Brilliant Green Lactose Bile Broth, and EMB agar), sterile water, pH buffer solutions for calibration (pH 4, 7, and 10), and deionized water for rinsing the electrode.

Instruments

The instruments used in this study included 300 mL BOD bottles with stoppers, a 20°C incubator, a dissolved oxygen (DO) meter or Winkler titration apparatus, volumetric pipettes, dispensers, a reactor or heating block, closed reflux tubes, a burette or autotitrator, a vacuum filtration unit, an oven maintained at 103–105°C, a desiccator, an analytical balance, a UV–Vis spectrophotometer, cuvettes, a separatory funnel or Soxhlet extraction apparatus, a water bath, a microbiological incubator (35–37°C), an autoclave, a sterile working area (laminar flow cabinet), a pH meter equipped with a glass electrode, and a thermometer.

Methods

Different analytical methods were employed to determine each parameter. Total suspended solids (TSS) and oil and grease were analyzed using the gravimetric method. Chemical oxygen demand (COD) was determined using the closed reflux dichromate titration method, while biochemical oxygen demand (BOD) was measured using the incubation method. Ammonia concentration was analyzed by spectrophotometric methods, pH was measured directly using a pH meter, and total coliform was determined using the Most Probable Number (MPN) method.

Results and Discussion

Wastewater treatment aims to separate or remove solid substances, both dissolved and suspended in water, as their presence can damage and interfere with subsequent wastewater treatment processes (Nurika & Suharti, 2018). Industrial wastewater treatment is essential for reducing the level of water pollution. This effort also seeks to prevent the occurrence of diseases and to protect human health as well as other ecosystems. To minimize the environmental impacts of wastewater, optimal treatment processes are required, which are typically preceded by research and development stages.

Wastewater that has undergone various treatment stages at CV PQR was analyzed for total suspended solids (TSS), chemical oxygen demand (COD), and biochemical oxygen demand (BOD). The results of these

e-ISSN: 3109-3825
https://e-journal.tematikapertanusantara.sch.id/index.php/SAR-Journal
Vol.1 (No.2): 77-85, 2025

analyses cover a six-month period in 2024, namely July, August, September, October, November, and December, as well as a two-month period in 2025, namely January and February. The data are presented in Table 1.

Table 1. Results of TSS, COD, and BOD Analysis

Month	Wastewater Test Results			Effluent Quality Standards			Unit
	TSS	COD	BOD	TSS	COD	BOD	
July	10,1	106,98	8,25	250	100	100	mg/L
August	8,2	377,15	10,8	250	100	100	mg/L
September	7,56	82,9	1,95	250	100	100	mg/L
October	9,87	33,53	3,25	250	100	100	mg/L
November	0,55	73,95	9,4	250	100	100	mg/L
December	7,56	7,879	7,9	250	100	100	mg/L
January	8,68	32,45	4,4	250	100	100	mg/L
February	22,1	58,33	28,6	250	100	100	mg/L

Source: Processed primary data, 2025

a. TSS

TSS represent solid particles that remain suspended in wastewater. In this study, TSS was measured using a gravimetric approach, which involves filtering the wastewater sample to capture suspended materials on filter media. The retained residues are subsequently dried and weighed to quantify the concentration of suspended solids (Prihatiningtyas & Purwanti, 2017). According to the Regulation of the Minister of Environment of the Republic of Indonesia No. 5 of 2014, the maximum permissible TSS level in effluent is 250 mg/L. As shown in Table 1, TSS concentrations recorded from July through February were within the specified regulatory limit, suggesting that the treated effluent is appropriate for environmental discharge or potential reuse.

b. COD

Elevated chemical oxygen demand (COD) levels can lead to a decrease in dissolved oxygen in water bodies, potentially causing disturbances to aquatic ecosystems. COD analysis in this study was carried out using the closed reflux dichromate titration technique, in which wastewater samples are reacted with potassium dichromate under acidic conditions and subjected to heating. The residual oxidizing agent is subsequently titrated to quantify the oxygen equivalent needed for the oxidation of organic matter (Maulidaah, 2016). In accordance with the Regulation of the Minister of Environment and Forestry of the Republic of Indonesia No. P.68/2016, the permissible limit for COD in wastewater is set at 100 mg/L. As shown in Table 1, COD values in July and August exceeded the effluent quality standards. According to Supriyantini et al. (2017), elevated COD levels may result from increased production activities during July and August, which lead to higher pollutant loads entering the wastewater treatment plant (WWTP) beyond

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https://e-journal.tematikapertanusantara.sch.id/index.php/SAR-Journal
Vol.1 (No.2): 77-85, 2025

its treatment capacity, thereby reducing treatment efficiency. Milk and yogurt production generate wastewater containing proteins, fats, and carbohydrates. When wastewater treatment is suboptimal, these compounds are not completely degraded, resulting in increased chemical oxygen demand required to oxidize organic substances and consequently higher COD values.

c. BOD

BOD represents the quantity of dissolved oxygen consumed by microorganisms during the aerobic degradation of organic substances (Santoso, 2018). In this study, BOD was determined using a five-day incubation procedure, with dissolved oxygen levels measured both prior to and following incubation to estimate microbial oxygen utilization (SNI 6989.72:2019). The permissible limit for BOD in industrial effluent, as stipulated in the Regulation of the Minister of Environment of the Republic of Indonesia No. 5 of 2014, is 100 mg/L. As indicated in Table 1, BOD concentrations recorded from July through February were within the prescribed standard. This finding suggests that pollutant levels in the treated wastewater are adequately controlled, enabling safe environmental discharge or potential reuse.

Subsequently, the outcomes of oil and grease as well as ammonia analyses conducted over an eight-month period—six months in 2024 (July to December) and two months in 2025 (January and February)—are summarized in Table 2.

Table 2. Results of Oil and Grease and Ammonia Analysis

Month	Wastewater Test Results		Effluent Quality Standards		Unit
	Oil and Grease	Ammonia	Oil and Grease	Ammonia	
July	5	0,55	10	25	mg/L
August	5	0,1	10	25	mg/L
September	5	0,1	10	25	mg/L
October	5	0,33	10	25	mg/L
November	5	0,13	10	25	mg/L
December	5	0,05	10	25	mg/L
January	5	0,01	10	25	mg/L
February	5	0,38	10	25	mg/L

Source: Processed primary data, 2025

d. Oil and Grease

Oil and grease layers on water surfaces can inhibit the penetration of sunlight into aquatic environments, thereby disrupting photosynthesis processes in aquatic plants and other aquatic organisms (Hardiana & Mukimin, 2014). Oil and grease analyses were conducted using the gravimetric method. Wastewater samples were extracted using non-polar solvents such as petroleum ether. The solvent was then evaporated, and the remaining oil and grease residue was weighed to determine its concentration (Pramesti & Kusuma, 2021). In accordance with the Regulation of the Minister of Environment of the Republic of

e-ISSN: 3109-3825
https://e-journal.tematikapertanusantara.sch.id/index.php/SAR-Journal
Vol.1 (No.2): 77-85, 2025

Indonesia No. 5 of 2014, the permissible limit for oil and grease in wastewater is set at 10 mg/L. The data presented in Table 2 show that the measured oil and grease levels largely remained below this threshold. This suggests that the wastewater is unlikely to cause adverse environmental impacts upon discharge.

e. Ammonia

The discharge of wastewater containing high ammonia concentrations into water bodies can lead to a reduction in dissolved oxygen levels. Consequently, aquatic organisms may experience oxygen deficiency, which can increase the risk of mortality among aquatic biota (Kartika & Wahyuningsih, 2019). Referring to the Regulation of the Minister of Environment of the Republic of Indonesia No. 5 of 2014, the maximum allowable concentration of ammonia in wastewater effluent is set at 25 mg/L.

As presented in Table 2, all observed ammonia levels were within the permitted limits, suggesting that the treated wastewater poses no significant environmental risk.

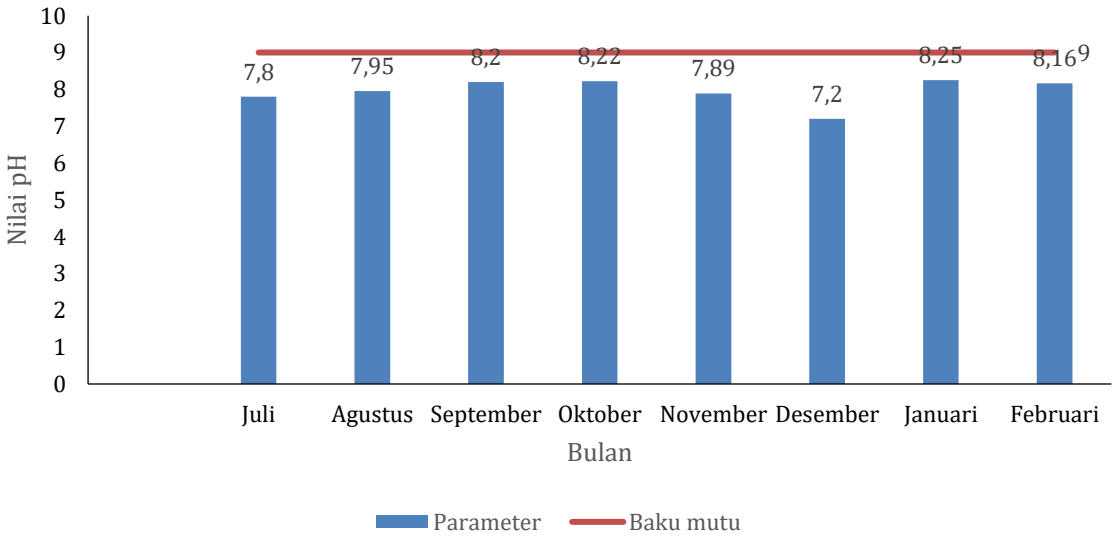

Figure 1. pH Test Results
Source: Processed primary data, 2025

f. pH

Untreated wastewater released into the environment may alter surrounding pH conditions, resulting in either acidic or alkaline aquatic environments. Such pH fluctuations can negatively affect the viability of aquatic organisms, including fish, flora, and other biota, and may also present potential threats to human health. In this study, pH levels were measured directly using a pH meter. Based on the Regulation of the Minister of Environment of the Republic of Indonesia No. 5 of 2014, the permissible pH range for wastewater effluent is 6–9. The results of the analysis demonstrate that the measured pH values fell within this acceptable range, indicating that the treated wastewater is suitable for discharge into the environment or for reuse.

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https://e-journal.tematikapertanusantara.sch.id/index.php/SAR-Journal
Vol.1 (No.2): 77-85, 2025

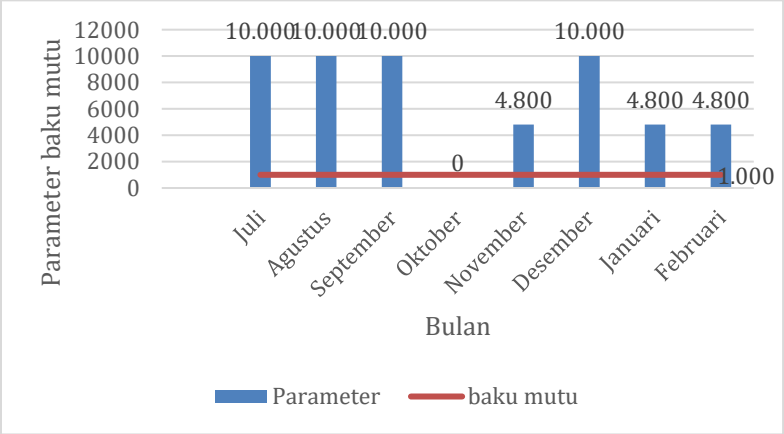

Figure 2. Total Coliform Test
Source: Processed primary data, 2025

g. Total Coliform

Coliform bacteria detected in water and wastewater can serve as indicators of contamination by microorganisms with pathogenic potential, thereby posing risks to human health (Sutiknowati, 2018). Total coliform concentrations were quantified using the Most Probable Number (MPN) technique, in which wastewater samples were serially diluted and cultured on selective media. The abundance of coliform bacteria was estimated based on gas production or observable color changes in the culture media. In accordance with the Decree of the Minister of Environment No. 51 of 2004, the maximum permissible concentration of coliform bacteria in wastewater effluent is 1,000 MPN/100 mL. Based on this criterion, compliance with the effluent quality standard was achieved only in samples collected during October. Elevated coliform levels recorded in the remaining months were associated with temporal variations in wastewater characteristics. The substantial daily wastewater volume, ranging from approximately 30 to 35 m^3, originated from multiple sources exhibiting diverse contaminant profiles. Effluents from milk processing activities are rich in organic compounds such as proteins, lipids, and carbohydrates, which provide suitable growth substrates for coliform bacteria. Higher organic loads promote rapid bacterial multiplication. Furthermore, environmental factors contribute to these dynamics; during the rainy season, coliform abundance may decline due to reductions in wastewater pH.

Conclusion

The evaluation of wastewater quality at CV PQR indicated that total suspended solids (TSS), pH, biochemical oxygen demand (BOD), chemical oxygen demand (COD) during the periods of September, October, November, December, and January, as well as oil and grease, ammonia, and total coliform in October, were within the effluent quality standards prescribed by the Regulation of the Minister of Environment of the Republic

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https://e-journal.tematikapertanusantara.sch.id/index.php/SAR-Journal
Vol.1 (No.2): 77-85, 2025

of Indonesia No. 5 of 2014. In contrast, COD concentrations measured in July and August exceeded the allowable limits specified in the same regulation. Furthermore, total coliform concentrations observed in July, August, September, November, December, January, and February were above the maximum thresholds defined in the Decree of the Minister of Environment No. 51 of 2004.

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Vol.1 (No.2): 77-85, 2025

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