EFFLUENT QUALITY TEST ON THE COMMUNAL WWTP IN BANDA ACEH CITY

Ikhwanul Muslimin[*], **Izarul Machdar**[**], **Nasrul Arahman**[**]
[*]*Department of Environmental Master's Program, Syiah Kuala University, Banda Aceh, Indonesia, ikhwanul.ibra@gmail.com*
[**]*Department of Chemical Engineering, Syiah Kuala University, Banda Aceh, Indonesia, machdar@unsyiah.ac.id, nasrular@unsyiah.ac.id*

Email Correspondence: ikhwanul.ibra@ gmail.com

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Abstract: One of the domestic wastewater management systems developed in Banda Aceh City is a settlement-scale centralized wastewater treatment plant, also known as the Communal WWTP system, with an anaerobic baffled reactor (ABR) and anaerobic filter (AF) configuration. This study aims to examine the quality of the effluent from the treatment of communal WWTPs in the city of Banda Aceh. Measurements of the contents of pH, BOD, COD, TSS, Ammonia, and Total Coliform were carried out on effluent samples from the communal WWTP and the results of the analysis were compared with the quality standards from the Minister of Environment and Forestry Regulation No. 68 of 2016 concerning Domestic Wastewater Quality Standards. The research showed that the pH, COD, BOD, and Ammonia parameters had met the quality standards, while the TSS and Total Coliform parameters at the five (5) locations of the communal WWTP studied had not shown effective performance and had not met the quality standards. The choice of technology configuration and management of communal WWTP is a factor that influences the processing performance and quality of communal WWTP effluent in Banda Aceh City.
Keywords: effluent; communal WWTP; Banda Aceh city

Abstrak: Salah satu sistem pengelolaan air limbah domestik yang dikembangkan di Kota Banda Aceh adalah SPALD-Terpusat skala permukiman, atau disebut juga dengan sistem IPAL Komunal, dengan konfigurasi *anaerobic baffled reactor* (ABR) dan *anaerobic filter* (AF). Penelitian ini bertujuan untuk menguji kualitas efluen hasil pengolahan IPAL komunal yang ada di kota Banda Aceh. Pengukuran kandungan pH, BOD, COD, TSS, Amonia serta *Total Coliform* dilakukan pada sampel efluen dari IPAL komunal dan hasil analisisnya dibandingkan dengan baku mutu Peraturan Menteri Lingkungan Hidup dan Kehutanan No. 68 Tahun 2016 tentang Baku Mutu Air Limbah Domestik. Penelitian menunjukkan parameter pH, COD, BOD dan Amonia telah memenuhi baku mutu sedangkan parameter TSS dan *Total Coliform* pada lima (5) lokasi IPAL komunal yang diteliti belum menunjukkan kinerja yang efektif dan belum memenuhi standar baku mutu. Pemilihan konfigurasi teknologi dan pengelolaan IPAL komunal menjadi faktor yang mempengaruhi kinerja pengolahan dan kualitas efluen IPAL komunal di Kota Banda Aceh.
Kata kunci: efluen; IPAL komunal; kota Banda Aceh

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Introduction

At present, the majority of residents in Banda Aceh City still use the local system domestic wastewater management system on an individual scale which is intended for 1 (one) residential unit, 1.55% of whom have never deslugged feces and some still use impermeable septic tanks that have the potential to pollute the environment (Banda Aceh City Sanitation Working Group, 2020). The results of the Environmental Health Risk Assessment (EHRA) study show that there are still urban residents in Banda Aceh who directly disposes of excrement in rice fields, gardens, or rivers. Almost 67.84% of residents in urban areas in Indonesia also practice similar behavior (Central Bureau of Statistics, 2020). In the Sanitation Strategy Update Book for the City of Banda Aceh 2020-2024, in 2016 it was recorded that water pollution originating from domestic wastewater caused severe pollution to water quality in the Krueng Aceh River. Of all the sources that cause domestic waste pollution, 50-80% came from water used for washing, kitchens, and bathrooms (Al Kholif, 2020). For this reason, it is necessary to have a processing step before the wastewater is channeled directly into the environment so that the risk of contamination of groundwater and water bodies can be avoided.

The government through the Ministry of Public Works and Public Housing issued Ministerial Regulation Number 04/PRT/M/2017 concerning the Implementation of Domestic Wastewater Management Systems, one of which is the Centralized Domestic Wastewater Management System (Ministry of PUPR, 2017). Communal WWTP works by receiving domestic wastewater originating from the wastewater collection channel to be processed in the WWTP before being discharged to the receiving body. Wastewater treatment in the communal WWTP in Banda Aceh is a series of biological processes with an anaerobic system. This system began to be applied in the 1980s and is considered suitable for tropical areas where the reactor can be operated at temperatures above 20°C (Foresti, 2002).

Anaerobic systems in communal WWTPs can help reduce contaminant levels from wastewater parameters (BOD, TSS, oil, and grease) with a fairly good level of effectiveness (Susanthi et al., 2018). Reducing the levels of contaminants in domestic wastewater is necessary because there are various compositions, namely, 40% food substances, 29% food additives, 9% dishwashing liquid, 14% residual detergent, 1% personal care products, 1% food residue disposal, and 6% of other substances that enter the sewers (Comber et al., 2013). Domestic wastewater originating from sinks, laundry, and dishwashing liquid also has higher levels of contaminants (Manna, 2018). Untreated domestic wastewater has an average concentration of Nitrogen of 35-100 mg/L and Phosphorus in the range of 18-29 mg/L (Rout et al., 2021). With high levels of contaminants, the domestic wastewater treatment process in the communal WWTP must work properly so that the discharged wastewater does not damage the environment (Sattuang et al., 2020). Because of that, the communal WWTP was finally chosen as an alternative strategy for solving the problem of domestic waste in the city of Banda Aceh.

In several other urban areas, the provision of communal WWTPs has not shown a significant contribution to reducing the level of contamination of water bodies, one of the reasons is that the quality standards for wastewater (effluent) have not been achieved so that it can reduce the quality of water quality in receiving water bodies (Hastuti et al. ., 2017). The performance of the communal WWTP is also greatly influenced by management aspects which could cause the not optimal wastewater treatment at the communal WWTP, due to the presence of scum during the sedimentation process which requires periodic cleaning (Kurnianingtyas et al., 2020).

This study aims to determine the quality of the effluent from the treatment of communal WWTPs in the city of Banda Aceh by testing the effluent samples based on the parameters stipulated by the Minister of Environment and Forestry Regulation No. 68 of 2016 concerning Domestic Wastewater Quality Standards.

Materials and Equipment

Wastewater samples from communal WWTP effluents were taken using the grab sampling referring to SNI 6989.59:2008, concerning Water and Wastewater – Section 59: Wastewater sampling methods. Wastewater samples were taken using a dipper and put into bottles for analysis in the laboratory, while the measurement of the pH value was carried out directly in the field using a pH meter. The sampling process can be seen in Figure 1.


(a) Ceurih WWTP


(b) Rukoh WWTP

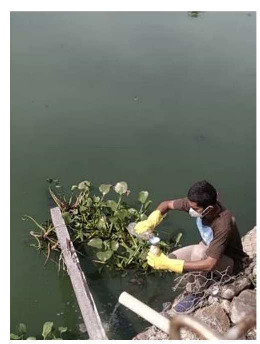
(c) Panteriek WWTP

Figure 1. Sampling of communal WWTP effluent

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Method

The study was carried out from April to June 2021, by taking a sample of 1 unit of communal WWTP at 5 (five) location points in the Banda Aceh City area. Determination of the sample for the Communal WWTP uses a purposive sampling technique with selection criteria including areas at risk of domestic wastewater with "very high" and "high" risk status which are priority areas, type of receiving water body, and year of construction starting 2015-2019. Data on the number of individual homes connected to WWTP for the communal WWTP in Banda Aceh City is listed in Table 1 and a map of the sampling location can be seen in Figure 2.

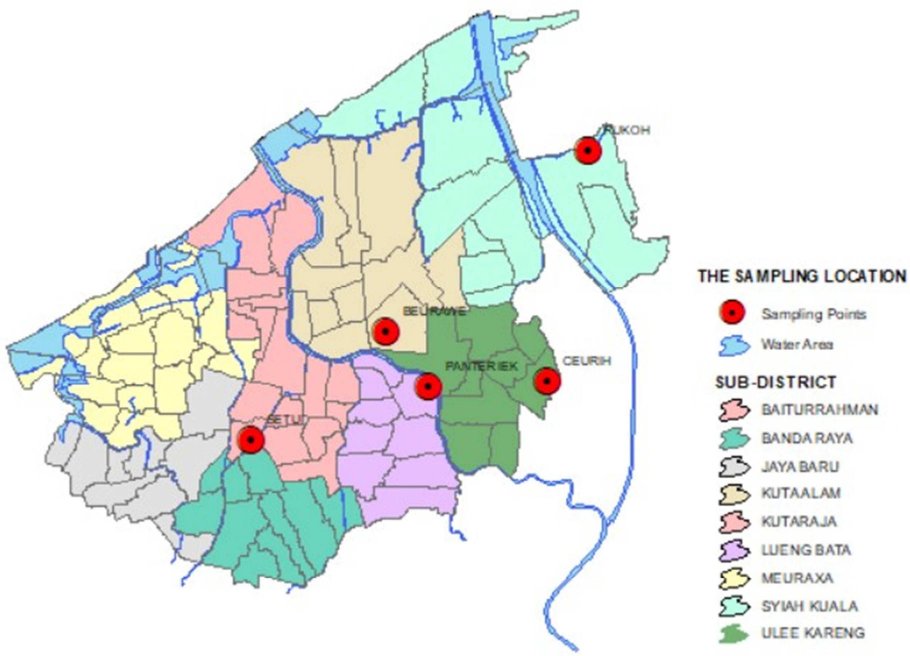


Figure 2. Map of the Sampling Location

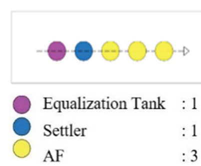
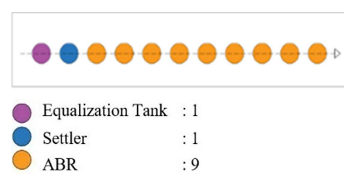
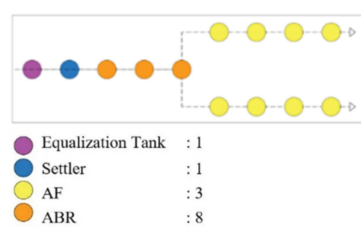
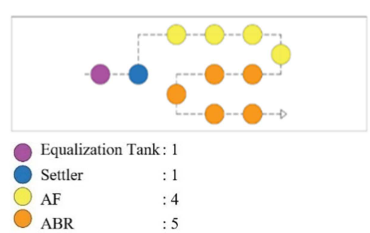
Table 1. Sample Locations for Communal WWTP

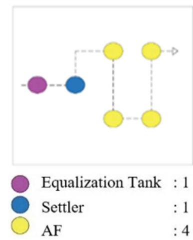
Name of WWTP	Number of Individual Homes	Coordinates	
		Latitude	Longitude
Rukoh WWTP	50	5.584891°	95.365498°
Ceurih WWTP	50	5.548406°	95.358788°
Beurawe WWTP	55	5.555138°	95.333147°
Panteriek WWTP	60	5.546156°	95.338803°
Seutui WWTP	57	5.541894°	95.314115°

Sampling started at 08.00-10.00 WIB (western Indonesian time) which is the highest time of household water use. From each WWTP, three (3) samples were taken at the same hour and on different days within a period of three (3) months to obtain accurate data and minimize errors in sampling. The samples taken were then taken to the Aceh Provincial Health Laboratory to be measured for the parameters BOD, COD, TSS, Ammonia, and Total Coliform with reference to the Minister of Environment and Forestry Regulation no. 68 of 2016 concerning Domestic Wastewater Quality Standards.

Sampling was carried out at the inlet and outlet of the Communal WWTP using Anaerobic Baffled Reactor (ABR) technology, Anaerobic Filter (AF), or a combination of the two technologies. The configuration of each communal WWTP sampled in this study is listed in Table 2 and a cross-sectional image of the Communal WWTP that combines ABR and AF technologies is shown in Figure 3.

Table 2. The Technology of Communal WWTP

WWTP	Technology	Illustration Configuration of WWTP
Rukoh	Anaerobic Filter (AF)	
Ceurih	Anaerobic Baffled Reactor (ABR)	
Beurawe	Combination of Anaerobic Filter (AF) and Anaerobic Baffled Reactor (ABR)	
Panteriek	Combination of Anaerobic Filter (AF) and Anaerobic Baffled Reactor (ABR)	

WWTP	Technology	Illustration Configuration of WWTP
Seutui	Anaerobic Filter (AF)	

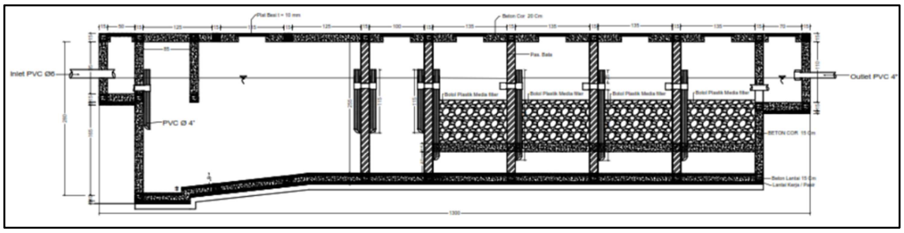


Figure 3. Cross-sectional image of the Panteriek Communal WWTP (ABR + AF Technology)

Results and Discussion

1. Degree of acidity (pH)

The degree of acidity (pH) is a measure used to express the level of acid or base possessed by a liquid. pH values below 7 are included in acidic conditions, neutral solutions have a pH value of 7, while alkaline conditions have values above 7-14 (Oktina, 2018). The measurement of the pH value was carried out directly at the sampling site with reference to the value of the wastewater quality standard (for the pH parameter) which is 6-9. The pH parameter test results are listed in table 3.

Table 3. Effluent Quality Test Results for pH Parameter

WWTP Location	Test I	Test II	Test III
Rukoh WWTP	7.2	7.3	7.4
Ceurih WWTP	7.4	7.6	7.5
Beurawe WWTP	7.0	6.9	7.1
Panteriek WWTP	7.1	7.1	7.0
Seutui WWTP	7.5	7.5	7.1

The results of this test show that the quality of the effluent in all samples is still in accordance with the wastewater quality standards stipulated in the Minister of Environment and Forestry Regulation No. 68 of 2016 for pH parameters in the value range of 6-9.

2. Biochemical Oxygen Demand (BOD)

BOD is the amount of dissolved oxygen present in the waters (Santoso, 2018). Biological oxygen demand is useful for determining water quality (Daroni & Arisandi, 2020). If the water test sample indicates a high BOD value, it indicates that the presence of organic matter which causes the growth of pathogenic bacteria to be in high numbers, causing a pungent odor in the water and disturbing the health of humans and animals (Ranudi, 2018).

Table 4. Effluent Quality Test Results for BOD Parameters

WWTP Location	Test I	Test II	Test III
Rukoh WWTP	16.3	11.4	33.8
Ceurih WWTP	17.2	13	19
Beurawe WWTP	20.7	52.1	39
Panteriek WWTP	6.3	17.6	22.1
Seutui WWTP	34.6	16	44.2

The test results show BOD levels that meet the standards of quality found in the Panteriek WWTP samples, but the effluent value which was consistently above the influent value indicated that the activity of microorganisms decomposing organic compounds in wastewater was not going well. It can be said that the performance of the Panteriek WWTP in eliminating BOD levels is still not effective.

From the graph shown, the BOD parameter test for 5 (five) sample units as a whole shows that WWTP management has not been effective. The behavior of the community using the communal WWTP which often disposes of oil that is not balanced with the process of cleaning the fat trap tub every 2 (two) weeks also influences the characteristics of the greywater that enters the WWTP. The high organic matter content that enters the WWTP has a major influence on the high BOD levels in the effluent of the communal WWTP (Wijayaningrat, 2018). The results of the BOD parameter test can be seen in figure 4.

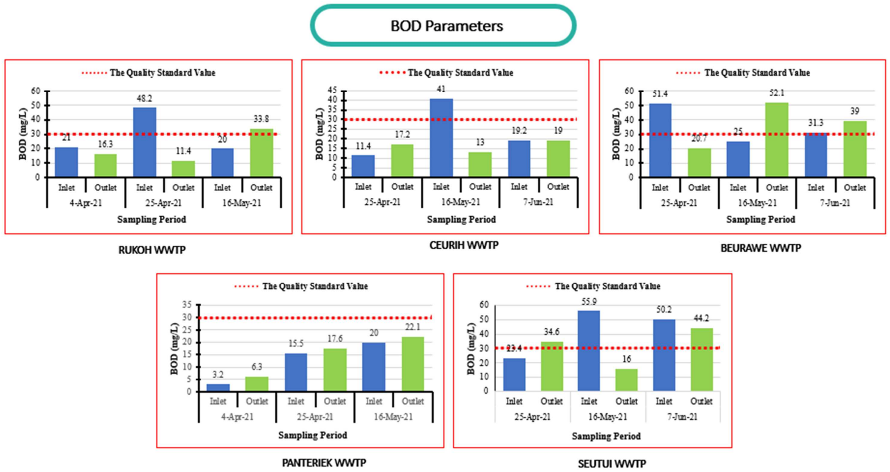


Figure 4. BOD parameter test results on 5 Communal WWTP units

3. Chemical Oxygen Demand (COD)

COD testing aims to measure the levels of organic matter in water which in natural processes can be oxidized by microbiological processes so that the amount of COD will affect the lack of dissolved oxygen (Putri Setyo Pratiwi, 2007).

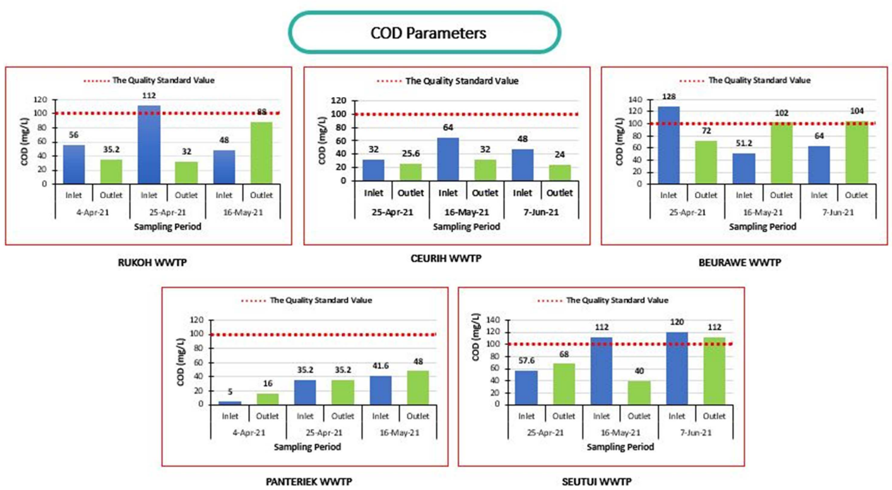


Figure 5. COD parameter test results on 5 Communal WWTP units

COD levels in accordance with quality standards were found in the Panteriek, Ceurih, and Rukoh WWTP samples, although in test III at Rukoh WWTP, a significant increase appeared which at the time of sampling could have been caused by a high load of organic (pollutant) so that the performance of the microorganism experienced a momentary shock. While consistently above the quality standard threshold was found in the Beurawe and Seutui WWTP samples.

The selection factor for the WWTP technology configuration also determines the effectiveness of COD removal. In several literature studies, ABR technology is very suitable for tropical areas which have a COD removal efficiency of between 40-75% (Pitoyo et al., 2017) and (Singh et al., 2009) 77%. Test results on samples from the Ceurih WWTP using ABR technology showed a better COD removal performance than the Rukoh WWTP using the AF system.

Based on research conducted by Ahmad (2017) the combination of ABR and AF technology in treating domestic waste can be more efficient in treating wastewater (Kurnianingtyas et al., 2020). The combination wastewater treatment process system starts from the sedimentation process to the ABR compartment, and finally to the AF compartment. The combination of these two systems allows for more efficient wastewater treatment so the ABR and AF combination system at the Panteriek WWTP should be able to treat wastewater better and more efficiently.

Even though the Panteriek WWTP has met the COD parameter quality standard, the effluent value which is above the influent value indicates that the wastewater treatment is not going well. The configuration of the Panteriek WWTP has a different sequence of compartments from the communal WWTP with similar technology listed in the literature review that has been previously studied. Combination systems usually use the ABR compartment model and the AF compartment, however, the Panteriek WWTP starts with the AF compartments followed by the ABR compartment as the final stage of wastewater treatment.

4. Total Suspended Solid (TSS)

TSS parameter test results in 3 (three) tests show results that are above the threshold and do not meet quality standards. Only the Ceurih WWTP in 2 (two) sample tests, has shown results that meet quality standards.

Table 5. Effluent Quality Test Results for TSS Parameters

WWTP Location	Test I	Test II	Test III
Rukoh WWTP	52	57	45
Ceurih WWTP	33	14	15
Beurawe WWTP	65	67	69
Panteriek WWTP	6	58	44
Seutui WWTP	60	57	79

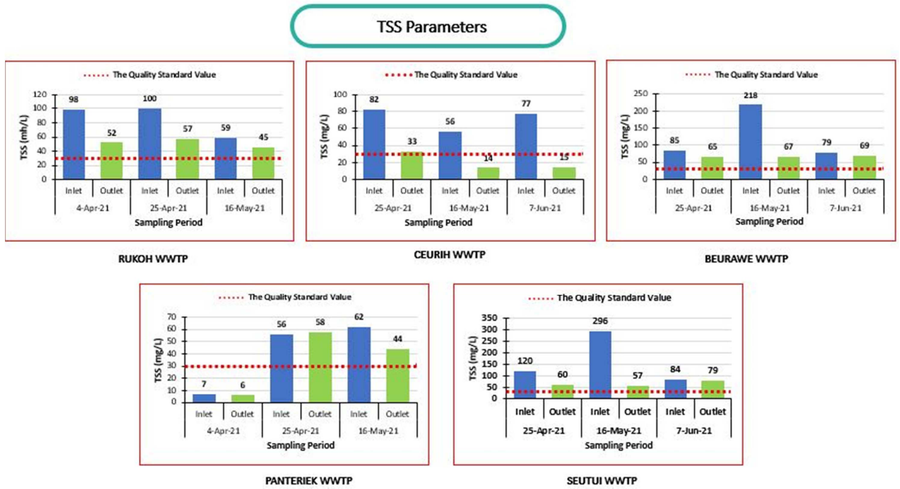


Figure 6. The results of the TSS parameter test

The performance of the communal WWTP is also strongly influenced by aspects of management and maintenance which could cause not optimal wastewater treatment at the communal WWTP. Sludge that is no longer active in the ABR and AF tanks is planned to be drained every two years. Drainage of inactive (black) sludge must be exhausted and when the sludge starts to turn brown, draining should be immediately stopped so as not to suck up activated sludge (Ministry of PUPR, 2013), because activated sludge can reduce total suspended solids (TSS) up to 91% (Nico, 2017).

Within 4 years after the construction of the communal WWTP in Panteriek, desludging has never been carried out. By not desludging, there is a layer of inactive sludge which reduces the effectiveness of TSS removal.

5. Ammonia (NH_3)

Testing for ammonia on samples showed consistent results: all samples had values below the threshold for NH_3: ≤ 10 mg/L and met the quality standards for ammonia content in the wastewater. However, in some effluent samples, the ammonia value has a greater value than the influent. This shows that the WWTP processing process in reducing ammonia is not going well. Wastewater flow discharge with a more stable flow and length of residence time are factors that can increase the effectiveness of reducing ammonia levels (Harahap, 2013)

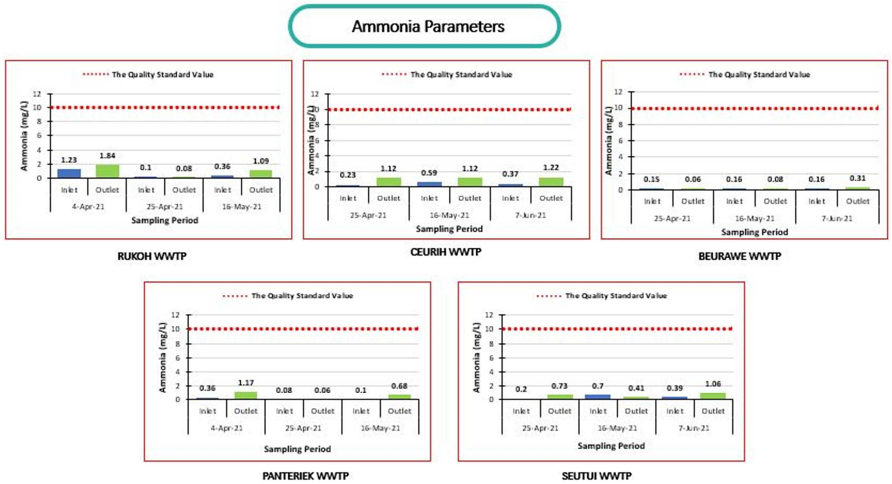


Figure 7. Test results for ammonia parameters

6. Total Coliform

Total coliform test results that consistently meet quality standards were found in Rukoh WWTP. While the total coliform from the other four WWTP samples showed a total coliform parameter threshold of ≤ 3000. Total coliform that contaminates receiving water bodies can cause adverse health effects if the water is consumed by humans, including diarrhea, typhoid, dysentery, and hepatitis (Ranudi, 2018).

Table 6. Effluent Quality Test Results for Total Coliform Parameter

WWTP Location	Test I	Test II	Test III
Rukoh WWTP	700	1100	2300
Ceurih WWTP	7900	21000	2200
Beurawe WWTP	8100	23000	3800
Panteriek WWTP	3800	17000	92000
Seutui WWTP	4000	92000	2100

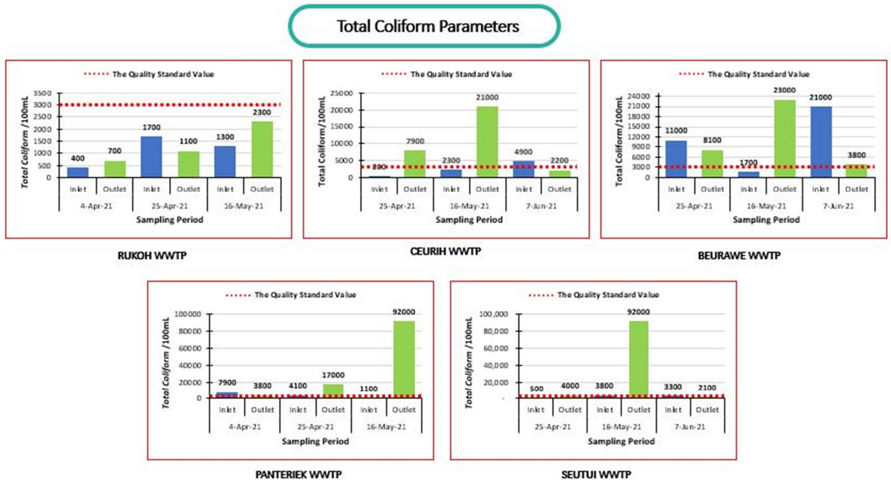


Figure 8. Total Coliform parameter test results

Conclusions

The effluent quality test for communal WWTPs in Banda Aceh City showed that the TSS and Total Coliform did not meet the domestic wastewater quality standards based on the Minister of Environment and Forestry Regulation No. 68 of 2016. The pH, COD, BOD, and Ammonia parameters have met the quality standards, but the effluent value which is often above the influent value indicates that the performance of the communal WWTP is not yet effective. The choice of technology configuration and management of the communal WWTP is a factor that influences the processing performance and effluent quality of the communal WWTP. Communal WWTP management needs to be improved so that it can operate properly and produce effluent that meets domestic wastewater quality standards.

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