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Evaluation of Wastewater Treatment Installations at Kendari City Hospital

Ranno Marlany Rachman[1*], Pidun[1], and Romy Talanipa[1]

[1]Jurusan Teknik Sipil, Program Studi Teknik Rekayasa Infrastruktur dan Lingkungan, Fakultas Teknik, Universitas Halu Oleo, Indonesia; e-mail: rannorachman@uho.ac.id

ABSTRAK

Rumah Sakit merupakan fasilitas publik yang menghasilkan limbah dalam jumlah besar dari berbagai aktivitas yang dilakukan di dalamnya, salah satunya adalah limbah cair yang mengandung zat berbahaya dan perlu diolah sebelum dibuang ke lingkungan. Penelitian ini bertujuan untuk mengevaluasi efektivitas kinerja Instalasi Pengolahan Air Limbah (IPAL) Rumah Sakit Daerah Kota Kendari serta untuk mengetahui kualitas air limbah setelah diolah, berdasarkan baku mutu Keputusan Menteri Lingkungan Hidup Nomor 5 Tahun 2014. Penelitian ini menggunakan metode deskriptif kuantitatif dengan pendekatan observasi, pengujian laboratorium, dan wawancara. Hasil penelitian pada bulan Agustus 2023 menunjukkan bahwa IPAL RSUD Kota Kendari berfungsi secara efektif dengan penurunan yang signifikan pada beberapa parameter, yaitu pH sebesar 1,40%, TSS (Total Suspended Solids) sebesar 68,00%, COD (Chemical Oxygen Demand) sebesar 51,10%, dan BOD (Biochemical Oxygen Demand) sebesar 86,70%, sedangkan suhu tidak mengalami perubahan. Pada bulan Desember 2023, efektivitas IPAL masih belum optimal, dengan nilai pH 9,38%, TSS 21,4%, COD 31,1%, BOD 32,7%, dan suhu meningkat sebesar 5,27%. Efluen RSUD Kota Kendari pada bulan Agustus 2023 memenuhi baku mutu Keputusan Menteri Lingkungan Hidup Nomor 5 Tahun 2014 dengan suhu 28°C, pH 7,34, TSS 71 mg/L, COD 18,70 mg/L, dan BOD 1,50 mg/L. Namun, pada bulan Desember 2023, meskipun efluen masih memenuhi sebagian besar baku mutu dengan nilai pH 6,76, TSS 22 mg/L, COD 23,8 mg/L, dan BOD 10,7 mg/L, suhu tercatat 31,1°C, yang melebihi batas baku mutu yang ditetapkan, yaitu 30°C.

***Kata kunci*:** air limbah, evaluasi, WWTP, rumah sakit

ABSTRACT

Hospitals are public facilities that generate large amounts of waste from various activities, including liquid waste containing hazardous substances that must be treated before discharge into the environment. This study aims to evaluate the performance of the Kendari City Regional Hospital Wastewater Treatment Plant (WWTP) and to determine the quality of wastewater after treatment, in accordance with the Minister of Environment Decree Number 5 of 2014. This study uses a quantitative descriptive method with an observation approach, laboratory testing, and interviews. The results of the survey in August 2023 showed that the Kendari City Regional Hospital WWTP functioned effectively with a significant decrease in several parameters, namely pH by 1.40%, TSS (Total Suspended Solids) by 68.00%, COD (Chemical Oxygen Demand) by 51.10%, and BOD (Biochemical Oxygen Demand) by 86.70%, while the temperature did not change. In December 2023, the wastewater treatment plant's effectiveness was still not optimal, with a pH of 9.38%, TSS of 21.4%, COD of 31.1%, BOD of 32.7%, and a temperature increase of 5.27%. The effluent from Kendari City Hospital in August 2023 met the quality standards set by the Minister of Environment Decree Number 5 of 2014, with a temperature of 28°C, pH of 7.34, TSS of 71 mg/L, COD of 18.70 mg/L, and BOD of 1.50 mg/L. However, in December 2023, although the effluent still met most quality standards—pH 6.76, TSS 22 mg/L, COD 23.8 mg/L, and BOD 10.7 mg/L —the temperature was 31.1°C, exceeding the set quality standard limit of 30°C.

***Keywords*:** wastewater, evaluation, WWTP, hospital

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1. INTRODUCTION

The high population in Indonesia has resulted in the need for adequate public facilities, including health facilities such as hospitals (Mahendradhata et al., 2021). A hospital is a facility that aims to be a place of service and a means of improving health through medical services such as treatment, prevention, and recovery (Capolongo et al., 2020).

There must be good and bad influences in every activity, including activities that take place in hospitals. The advantage of desired hospital services is that they do not cause obstacles but provide benefits (Khan et al., 2024).

However, the negative impacts are paid attention to so as not to disturb the surrounding environment. Apart from that, hospitals as public facilities also have a negative effect, producing waste from various activities within them. The waste produced can be solid, liquid or gas (Maharani and Prakoso, 2023). Hospital wastewater is the water waste from hospital operations, including faeces, that may contain harmful substances like toxins, radioactive materials, and blood, posing health risks (Khan et al., 2021).

Wastewater sources from hospitals are divided into three main categories: domestic waste, waste originating from medical activities, and waste from laboratory activities (Timofeeva and Bodienkova, 2021). Liquid waste from hospitals tends to pose more significant risks to health, so it is important to process it before being discharged into the environment. Considering the higher risk of liquid waste generated by hospitals, it is important to treat it properly before disposal (Wisniewski et al., 2020).

Before being released into nature, wastewater must undergo a series of treatment processes at wastewater treatment facilities to reduce the concentration of dangerous substances and become suitable and safe for further processing or disposal. (Syamsul, 2021).

Wastewater Treatment Plant is an infrastructure specifically created to handle liquid waste from hospitals, considering various types of waste from multiple sources (Yan et al., 2020). The main function of WWTP is to avoid environmental pollution and maintain health, especially for waste management workers and residents around health facilities, who may be affected by exposure to liquid medical waste (Kesari et al., 2021).

Kendari City Regional General Hospital is a type B health facility that provides various specialist and subspecialist medical services with limited capacity. There are plans to establish type B hospitals in each province as referral centres for hospitals at the district level. Kendari City Hospital is equipped with 200 beds. This hospital is also integrated with a WWTP system that applies AOP (Advanced Oxidation Process) technology to treat wastewater before it is released into nature. Wastewater Treatment Plants that utilize Advanced Oxidation Systems or AOP (Advanced Oxidation Processes) are the main method for producing hydroxyl radicals (˙OH). These strong oxidizing species efficiently degrade organic and inorganic substances and effectively eliminate bacteria and viruses in liquid waste.

Based on information from the liquid waste management at the Kendari City Hospital, there is already a Wastewater Treatment Plant (WWTP), which has been operating since 2013. However, due to some damage, the installation was replaced with a new WWTP in 2020, which uses Oxidation System technology. Advanced Level or AOP (Advanced Oxidation Processes) is still actively used today. Inspection of the quality of processed wastewater is carried out twice a year. Still, there has been no study on the performance of the wastewater treatment installation at the Kendari City Regional Hospital. Thus, it is important to conduct research regarding the efficiency of wastewater treatment to assess the effectiveness of the Kendari Wastewater Treatment Plant unit in processing wastewater. Apart from that, find out how much the wastewater content compares before and after processing.

2. METHODOLOGY

2.1. Time and Place of Research

This research was carried out in December 2023. The place or research location was at the Research Location, and water sampling was carried out at the Kendari City Regional Hospital.

The location of the laboratory examination was located at the Regional Technical Implementation Unit Laboratory of the Southeast Sulawesi Provincial Environmental Service.

2.2. Data Collection and Analysis Techniques

In this research, a quantitative descriptive approach was applied, including observation, laboratory analysis, and interviews. The observation approach was used to assess the operational conditions of the Wastewater Treatment Plant (WWTP) at Kendari City Regional Hospital. A detailed figure illustrating the wastewater treatment process was provided to clearly present the various stages of treatment. The research also explained the methods used for each parameter:

- pH was measured using a pH meter to assess the acidity or alkalinity of the wastewater.
- Temperature was recorded with a thermometer to monitor temperature variations during treatment.
- Total Suspended Solids (TSS) were analyzed through filtration and drying techniques to measure the solid particles in the wastewater.
- Chemical Oxygen Demand (COD) was tested using titration to determine the oxygen required to oxidize organic pollutants.
- Biochemical Oxygen Demand (BOD) was measured by incubating the samples to observe the oxygen consumed by microorganisms in breaking down organic matter.

By understanding the efficiency of the waste processing system, we can assess whether each stage or unit in the system is operating according to expectations or not. Effectiveness analysis using the formula:

$$E = (S0 - S)/(S0) \times 100\% \quad \ldots (1)$$

Information:

E = Effectiveness of wastewater treatment at WWTP (%)

S0 = Average concentration of parameters at the inlet (mg/L)

S = Average parameter concentration at the outlet (mg/L)

Then, the calculation results can be compared with the minimum percentage value written by (Susanti dkk., 2020). The percentage values are as follows:

1. Very efficient: X > 80%
2. Efficient: 60% < X ≤ 80%
3. Fairly efficient: 40% < X ≤ 60%
4. Less efficient: 20% < X ≤ 40%
5. Inefficient: X ≤ 20%

3. RESULTS AND DISCUSSION

Effectiveness of the performance of the wastewater treatment installation (WWTP) of the Kendari City Regional Hospital. Based on the results of laboratory tests on wastewater samples in August and December 2023, the following results were obtained in Table 1.

The wastewater treatment process at Kendari City Hospital shows varying effectiveness across parameters. pH remains within the acceptable range (7.45 to 7.34), and temperature stays stable at 26°C, well below the 38°C limit. The treatment effectively reduces COD (38.3 to 18.7 mg/L) and BOD (8.7 to 1.5 mg/L), meeting regulatory standards. However, TSS remains above the permissible limit, decreasing from 222 mg/L to 71 mg/L, exceeding the 30 mg/L standard. The wastewater treatment process at Kendari City Hospital showed quite promising results, although several parameters still need improvement. For BOD, there was a notable decrease from 8.7 mg/L to 1.5 mg/L (82.18% efficiency), which is impressive and meets quality standards. This result is comparable to that of Anna Medika Hospital in Madura, which achieved a 98% reduction in BOD (Fitria, 2025). As for COD, the decrease from 38.3 mg/L to 18.7 mg/L (51.2% efficiency) is still effective, although it doesn't quite match the performance of Dr H. A. Rotinsulu Lung Hospital, where COD was reduced by 71.5% (Wibowo et al., 2023). However, for TSS, despite a significant decrease from 222 mg/L to 71 mg/L (68.0% efficiency), the result still exceeds the established quality standard of 30 mg/L. This suggests that, while there has been a reduction, TSS treatment efficiency at Kendari City Hospital still requires enhancement. This contrasts with Hospital X Gresik, which achieved an impressive 88.15% reduction in TSS (Auliya & Cundaningsih, 2025). While the system efficiently reduces organic pollutants, further improvements are needed to lower TSS levels to meet compliance.

Based on the inspection results presented in Table 2 for December 2023, the pH values of the inlet wastewater samples ranged from 7.1 to 7.7, which remain within the acceptable quality standard range of 6-9. The temperature of the inlet wastewater fluctuated between 29°C and 30.5°C, which is still below the maximum allowable limit of 38°C according to Minister of Environment Decree No. 5 of 2014. These results indicate that the incoming wastewater maintains relatively stable pH and temperature conditions, suggesting that external factors do not significantly impact these parameters before treatment. However, considering the effectiveness of the wastewater treatment process, further evaluation is necessary to ensure that treated wastewater continues to meet regulatory standards, particularly for parameters that exhibited inconsistencies in previous assessments.

Based on the inspection results presented in Table 3 for December 2023, the pH values of the outlet wastewater samples ranged from 6.3 to 7.1, which are still within the acceptable range of 6-9 according to Minister of Environment Decree No. 5 of 2014. However, the pH value at 09:50 was at the lower limit (6.3), indicating potential fluctuations in the treatment process. The outlet temperature ranged from 31°C to 31.5°C, which, while still below the maximum allowable limit of 38°C, showed an increase compared to the inlet temperature recorded in Table 2 (29°C - 30.5°C). This suggests that the wastewater treatment process may contribute to a slight increase in temperature, which needs further monitoring to ensure long-term compliance. Overall, while the pH and temperature parameters remain within acceptable limits, their variations indicate the need for continuous assessment to maintain stable wastewater quality.

Table 1. Results of Pollution Parameter Checks in August 2023

No	Parameters	Unit	Results		Quality standards
			Inlet	Outlet	
1	pH	-	7,45	7,34	9-Jun
2	Temperature	^{0}c	26	26	38
3	Total Suspended Solid (TSS)	Mg/L	222	71	30
4	Chimical Oxsigen Demand (COD)	Mg/L	38,3	18,7	80
5	Biological Oxsigen Demand (BOD)	Mg/L	8,7	1,5	50

Table 2. Results of Temperature and pH Parameter Inspection of Inlet Samples in December 2023

No	Time (WITA)	Parameters	
		(pH)	Temperature (^{0}c)
1	9.22	7,6	29
2	13.42	7,1	30,5
3	16	7,7	29,5

Table 3. Outlet Sample Temperature and pH Parameter Inspection Results in December 2023

No	Time (WITA)	Parameter	
		(pH)	Temperature (°c)
1	9.5	6,3	31
2	13.45	7,1	31,5
3	16.06	6,9	31

Table 4. Pollution Parameter Check Results in December 2023

No	Parameters	Unit	Results		Quality standards
			Inlet	Outlet	
1	Total Suspended Solid (TSS)	mg/L	28	9-Jun	30
2	Chimical Oxsigen Demand (COD)	mg/L	34,6	38	80
3	Biological Oxsigen Demand (BOD)	mg/L	15,9	30	50

Table 5. Calculation Results of the Effectiveness of Kendari City Regional Hospital Wastewater Treatment Plants Based on Pollution Parameters in August 2023

No	Parameter	Unit	Results		Quality standards	Percentage (%)		Effectiveness
			Inlet	Outlet		Decline	Increase	
1	pH	-	7,45	7,34	9-Jun	1,4%	-	efficient
2	Temperature	°c	26	26	28	0,0%	-	efficient
3	Total Suspended Solid (TSS)	Mg/L	222	71	30	68,0%	-	efficient
4	Chemical Oxygen Demand (COD)	Mg/L	38,3	18,7	80	51,1%	-	quite efficient
5	Biological Oxygen Demand (BOD)	Mg/L	8,7	1,5	50	82,7%	-	quite efficient

Based on the results of pollution parameter monitoring in December 2023, presented in Table 4, the wastewater treatment process at Kendari City Hospital showed varying effectiveness. Total Suspended Solids (TSS) at the inlet was recorded at 28 mg/L, well below the 30 mg/L quality standard. However, discrepancies were noted in the outlet values, which ranged from 6 to 9 mg/L, requiring further clarification. Chemical Oxygen Demand (COD) increased from 34.6 mg/L at the inlet to 38 mg/L at the outlet, although still below the 80 mg/L quality standard. This increase indicates potential inefficiencies in the treatment process that require further investigation. Meanwhile, Biological Oxygen Demand (BOD) increased from 15.9 mg/L at the inlet to 30 mg/L at the outlet, although it still met the 50 mg/L quality standard.

For comparison, research by Mulyawati (2021) at Sulianti Saroso Hospital in Jakarta showed a reduction in BOD, COD, and TSS levels in hospital wastewater after treatment. Although the initial and final BOD, COD, and TSS values were not specifically stated, this study demonstrated that hospital wastewater treatment can effectively reduce these parameters, consistent with results obtained at Kendari City Hospital.

Furthermore, research by Nurhayati and Soleh (2020) at Sumedang Regency General Hospital demonstrated the effectiveness of wastewater

Demand (BOD) decreased by 82.75%, which shows that the Kendari City Hospital WWTP is very efficient in reducing Biochemical Oxygen Demand (BOD) parameters because the percentage is more than 80%. treatment plants in reducing BOD, COD, and TSS levels. The results of this study indicate that hospital wastewater treatment can be effective in reducing these parameters, although the initial and final BOD, COD, and TSS values were not reported.

Based on Table 5, the effectiveness of the Kendari City Hospital WWTP is based on pollution parameters in August 2023. In the pH parameter, there was a decrease of 1.4%; this percentage shows that the Kendari City Hospital WWTP is not efficient in reducing pH parameters because the percentage is less than 20%. The temperature decreased by 0%; this percentage shows that the Kendari City Hospital WWTP is inefficient in reducing pH parameters because the percentage is less than 20%. Even though pH reduction is not efficient, it still falls within the established quality standards, according to (Wibowo et al., 2023). Changes in air pH values become higher because they are contaminated with sand piles containing calcium.

Total Suspended Solid (TSS) decreased by 68.0%; this percentage shows that the Kendari City Hospital WWTP efficiently reduces the Total Suspended Solid (TSS) parameter because the percentage is less than 60% -80%. Chimical Oxygen Demand (COD) decreased by 51.17%, which shows that the Kendari City Hospital WWTP is quite efficient in reducing Chimical Oxygen Demand (COD) parameters because the percentage is less than 40% -60%. Biochemical Oxygen

The processing system at the IPAL is considered to be working quite well. This is indicated by the decrease in the COD, BOD and TSS parameter numbers (Putri and Hardiansyah, 2022).

Table 6. Calculation Results of the Effectiveness of Kendari City Regional Hospital WWTP Based on Pollution Parameters in December 2023

No	Parameters	Sat	Results		Quality Standard	Percentage (%)		Effectiveness
			Inlet	Outlet		decline	increase	
1	pH	-	7,46	6,76	9-Jun	9,38	-	efficient
2	Temperature	^{0}c	29,6	31,1	28	-	-5,27	efficient
3	Total Suspended Solid (TSS)	Mg/L	28	22	30	21,4%	-	less efficient
4	Chemical Oxygen Demand (COD)	Mg/L	34,6	23,8	80	31,2%	-	less efficient
5	Biological Oxygen Demand (BOD)	Mg/L	15,9	10,7	50	32,7%	-	less efficient

Based on Table 6, the effectiveness of the Kendari City Hospital WWTP was based on pollution parameters in December 2023. In the pH parameter, there was a decrease of 9.38%. This percentage shows that the Kendari City Hospital WWTP is inefficient in reducing pH parameters because the percentage is less than 20%. There was an increase of 5.27% in the temperature parameter, which shows that the Kendari City Hospital WWTP is inefficient in reducing temperature parameters because the percentage is less than 20%. Total Suspended Solid (TSS) increased by 21.4%; this percentage shows that the Kendari City Hospital WWTP is less efficient in reducing the Total Suspended Solid (TSS) parameter because the percentage is less than 20% -40%. Chimical Oxygen Demand (COD) increased by 31.21%; this percentage shows that the Kendari City Hospital WWTP is less efficient in reducing Chimical Oxygen Demand (COD) parameters because the percentage is less than 20% - 40%. Biochemical Oxygen Demand (BOD) increased by 32.70%, which shows that the Kendari City Hospital WWTP is less efficient in reducing Biochemical Oxygen Demand (BOD) parameters because the percentage is between 20% and 40%.

3.1. Quality Standards for Liquid Waste at Kendari City Regional Hospital

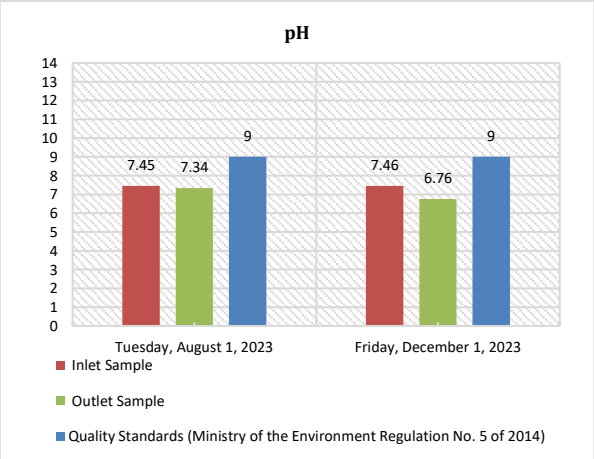

Figure 1. Comparison Graph of pH Parameters

Based on Figure 1, tests carried out in August 2023, wastewater samples before processing (inlet) and after processing (outlet) experienced a decrease of 0.11. This decreasing figure means that the quality of wastewater in terms of the degree of acidity (pH) parameter is still at the standard number of quality standards, namely 6-9, determined by the Minister of Environment Regulation No. 5 of 2014. Meanwhile, in December 2023, wastewater samples before processing (inlet) and after processing (outlet) decreased by 0.70. This decreasing figure means that the quality of wastewater in terms of the degree of acidity (pH) parameter is still at the standard number of quality standards, namely 6-9, determined by the Minister of Environment Regulation No. 5 of 2014.

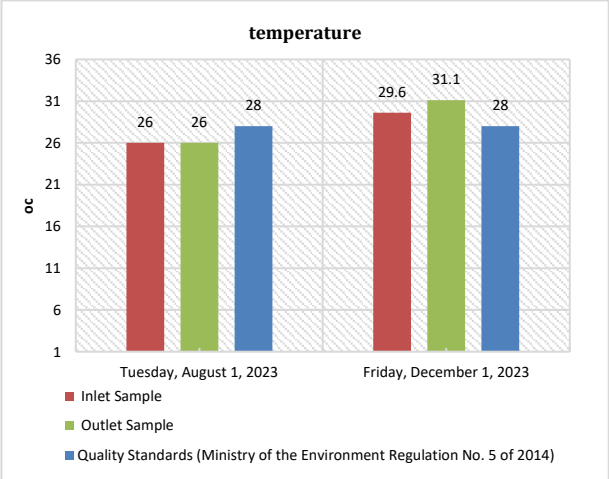

Figure 2. Comparison Graph of Temperature Parameters

Based on Figure 2 on the bag, in tests carried out in August 2023, it was recorded that there was no change in the value of the wastewater samples before (inlet) and after (outlet) the processing process. This value is still below the specified quality standard, namely 28^{o}C, by the Minister of the Environment Regulation No. 5 of 2014. Meanwhile, in December 2023, there was an increase of 1.50^{o}C in wastewater samples from the inlet to the outlet after processing. This increase in numbers means that wastewater quality in terms of temperature parameters has exceeded the quality standard, namely 28^{o}C, set by the Minister of Environment Regulation No. 5 of 2014.

Based on Figure 3, in August 2023, tests were carried out on wastewater samples before (inlet) and after (outlet) the processing process, which decreased by 151 Mg/l. This decrease resulted in the quality of wastewater in the Total Suspended Solids (TSS) parameter being recorded as lower than the permitted standard, namely 200 Mg/l, by the Regulation of the Minister of the Environment Number 5 of 2014. In December 2023, 6 Mg/l in wastewater samples will be reduced from the inlet to the exit point (outlet) after processing. This decrease causes wastewater's total

suspended solid (TSS) value to remain below the specified quality standard, namely 200 Mg/l, according to the Minister of Environment Regulation Number 5 of 2014. Reducing TSS levels can be done by coagulation and flocculation, and filtering can be done at each inlet tank, but routine maintenance must be carried out so that the filter is not clogged (Bhagavatula et al., 2021). The decrease in TSS parameters was caused by microorganisms being covered by TSS solids. In addition, this decline can occur due to the death of microorganisms that cannot survive in the new environment (John et al., 2021).

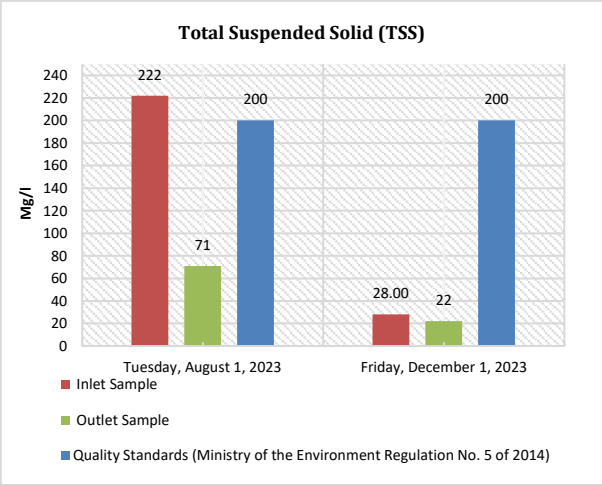

Figure 3. Comparison Graph of TSS Parameters

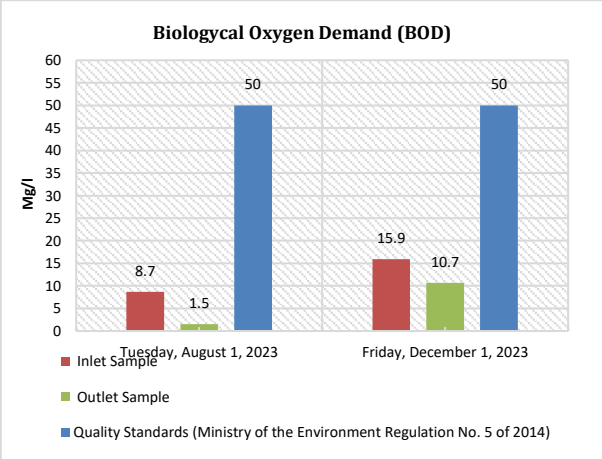

Figure 4. Comparison Graph of BOD Parameters

Based on Figure 4, tests carried out in August 2023, wastewater samples before processing (inlet) and after processing (outlet) experienced a decrease of 7.2 Mg/l. This decreasing figure means that wastewater quality in Biological Oxygen Demand (BOD) parameters is still below the quality standard, namely 50 Mg/l, as determined by the Minister of Environment Regulation No. 5 of 2014. Meanwhile, in December 2023, wastewater samples before processing (inlet) and after processing (outlet) decreased by 5.2 Mg/l. This decreasing figure means that wastewater quality in the Biological Oxygen Demand (BOD) parameter is still at the standard figure of the quality standard, namely 50 Mg/L set by the Minister of Environment Regulation No. 5 of 2014. According to (Harefa et al., 2021) domestic waste contains a lot of organic substances so it requires more oxygen to degrade these substances.

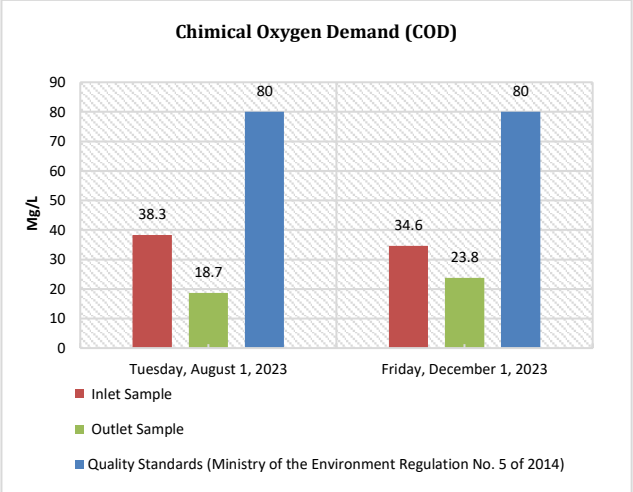

Figure 5. Comparison Graph of COD Parameters

Based on Figure 5, tests carried out in August 2023 of wastewater samples before processing (inlet) and after processing (outlet) experienced a decrease of 19.6 Mg/l. This decreasing figure means that wastewater quality in the Chemical Oxygen Demand (COD) parameter is still below the quality standard, namely 80 Mg/l, determined by the Minister of Environment Regulation No. 5 of 2014. Meanwhile, in December 2023, wastewater samples before processing (inlet) and after processing (outlet) decreased by 10.8. This decreasing figure means that the quality of wastewater in the Chemical Oxygen Demand (COD) parameter is still below the quality standard, namely 80 Mg/l, set by Minister of Environment Regulation No. 5 of 2014.

4. CONCLUSION

Based on the research results regarding the evaluation of wastewater treatment plants, it can be concluded that the effectiveness of waste processing at Kendari City Hospital varied between the two observation periods. In August 2023, the wastewater treatment functioned effectively, as indicated by a decrease in the levels of pH, TSS, COD, and BOD parameters, with the temperature parameter remaining stable. However, in December 2023, the effectiveness declined, as although there was still a reduction in pH, TSS, COD, and BOD levels, the temperature parameter increased. Furthermore, the test results showed that in August 2023, the outlet wastewater met the quality standards set by Minister of Environment Decree No. 5 of 2014 concerning hospital wastewater quality standards. In contrast, in December 2023, while most parameters remained within the acceptable range, the temperature parameter exceeded the permissible limit, indicating a decline in treatment efficiency during this period.

REFERENCE

Auliya, F. N., & Cundaningsih, N. (2025). Efisiensi Penghilangan Polutan Limbah Cair Rumah Sakit X melalui Instalasi Pengolahan Air Limbah. *Jurnal Serambi Engineering*, *10*(3).

Bhagavatula, A., Rajagopalan, V., Duncan, B. and Vimalchand, P., 2021. Innovative recovered water process implementation: Flocculation-sedimentation-filtration process for addressing water and energy nexus challenges at Kemper IGCC Power Plant. *Energy Nexus*, *1*, p.100007.

Capolongo, S., Gola, M., Brambilla, A., Morganti, A., Mosca, E. I., & Barach, P. (2020). COVID-19 and healthcare facilities: a decalogue of design strategies for resilient hospitals. *Acta Bio Medica: Atenei Parmensis*, *91*(9-S), 50.

Fitria, Y. (2025). Penurunan Bod dan Cod Dengan Metode Pembibitan Bakteri Pada Ipal Aerob Anaerob. *Jurnal Ilmiah Kesehatan Media Husada*, *14*(1), 103-110.

Harefa, N., Gulo, A. and Silaban, S., 2021. Analysis of BOD and COD levels for home industry wastewater: A case study in a sewage streams. *Jurnal Pendidikan Kimia*, *13*(1).

John, C.K., Pu, J.H., Pandey, M. and Moruzzi, R., 2021. Impacts of sedimentation on rainwater quality: case study at Ikorodu of Lagos, Nigeria. *Water Supply*, *21*(7), pp.3356-3369.

Kesari, K.K., Soni, R., Jamal, Q.M.S., Tripathi, P., Lal, J.A., Jha, N.K., Siddiqui, M.H., Kumar, P., Tripathi, V. and Ruokolainen, J., 2021. Wastewater treatment and reuse: a review of its applications and health implications. *Water, Air, & Soil Pollution*, *232*, pp.1-28.

Khan, N.A., Vambol, V., Vambol, S., Bolibrukh, B., Sillanpaa, M., Changani, F., Esrafili, A. and Yousefi, M., 2021. Hospital effluent guidelines and legislation scenario around the globe: A critical review. *Journal of Environmental Chemical Engineering*, *9*(5), p.105874.

Khan, M. T., Ahmad, R., Liu, G., Zhang, L., Santagata, R., Lega, M., & Casazza, M. (2024). Potential environmental impacts of a hospital wastewater treatment plant in a developing country. *Sustainability*, *16*(6), 2233.

Maharani, A.E. and Prakoso, A.L., 2023. Pengelolaan Limbah Medis di Rumah Sakit Berorientasi pada Greenhospital. *Health Information: Jurnal Penelitian*, pp. e1187-e1187.

Mahendradhata, Y., Andayani, N. L. P. E., Hasri, E. T., Arifi, M. D., Siahaan, R. G. M., Solikha, D. A., & Ali, P. B. (2021). The capacity of the Indonesian healthcare system to respond to COVID-19. *Frontiers in public health*, *9*, 649819.

Minister of Environment of the Republic of Indonesia. (2014). *Regulation No. 5 of 2014 concerning Effluent Quality Standards*. Ministry of Environment.

Mulyawati, I. (2021). Penurunan kadar BOD, COD, dan TSS pada air limbah rumah sakit. *Jurnal Teknik Lingkungan, 22*(3), 150–160

Nurhayati, & Soleh. (2020). Analisis efektivitas instalasi pengolahan air limbah (IPAL) di Rumah Sakit Umum Daerah Kabupaten Sumedang dengan parameter BOD, COD, dan TSS. *Jurnal Teknik Lingkungan, 21*(2), 112–121

Putri, N.M. dan Hardiansyah, F. (2022) 'Efektivitas Penerapan Teknologi Pada IPAL Komunal Ditinjau Dari Parameter BOD, COD, dan TSS', Jurnal Teknik Pengairan: Journal of Water Resources Engineering, 13(2), hlm. 183-194.

Susanti, A.R., Rustanti, I.E.W., Ngadino, Rokhmalia, F. 2020, 'Evaluasi Pengelolaan Instalasi Pengolahan Air Limbah Puskesmas', Jurnal Kesehatan, 11(2), pp. 204

Syamsul, M., 2021. BAB 4 Manajemen Pengelolaan Air Limbah Dan Tinja. *Kesehatan lingkungan suatu pengantar*, p.42.

Timofeeva, S.S. and Bodienkova, G.M., 2021, October. Medical Waste as a Source of Antibiotic Contamination in Wastewater. In *IOP Conference Series: Earth and Environmental Science* (Vol. 866, No. 1, p. 012014). IOP Publishing.

Wibowo, A., Hotmaida, L., Yogisutanti, G. (2023) 'Efektivitas Instalasi Pengolahan Air Limbah Secara Biologis Aerobik terhadap Penurunan Kadar COD, BOD, PH, TSS dan MPN Coliform di Rumah Sakit', Jurnal Ilmu Kesehatan Immanuel, 17(1), pp. 46. p-ISSN: 1410-234X, e-ISSN: 2597-9639.

Wisniewski, A., Zimmerman, M., Crews, T., Haulbrook, A., Fitzgerald, D. C., & Sistino, J. J. (2020). Reducing the impact of perfusion medical waste on the environment. *The Journal of ExtraCorporeal Technology*, *52*(2), 135-141.

Yan, S., Zhang, X. L., Tyagi, R. D., & Drogui, P. (2020). Guidelines for hospital wastewater discharge. In *Current developments in biotechnology and bioengineering* (pp. 571-597). Elsevier.