Jurnal Serambi Engineering JSE
Volume IX, No.4, Oktober 2024 Hal 11185 - 11191
p-ISSN : 2528-3561
e-ISSN : 2541-1934

Analysis of COD and BOD_5 at the Inlet and Outlet of the Wastewater Treatment Plant (WWTP) at Hospital X

Sunardi[1*], Fakhrizal Falah[1], Argoto Mahayana[1], Sumardiyono[2], Nur Hidayati[3], Soebiyanto[3], Mahardira Dewantara[4]

[1]Chemical Analyst Study Program, Faculty of Engineering, Setia Budi University, Surakarta
[2]Chemical Engineering Study Program, Faculty of Engineering, Setia Budi University, Surakarta
[3]Health Analyst Study Program, Faculty of Health Science, Setia Budi University, Surakarta
[4]Electromedical Engineering Technology, PKU Muhammadiyah Surakarta,
Institute of Science and Health Technology
***Corresponding author**: sunardi@setiabudi.ac.id

Received: October 3, 2024 Approved: October 11, 2024

Abstract
Hospitals are one of the service facilities that produce large amounts and quality of liquid waste that requires special attention because it contains hazardous materials for public health and the environment. This study aims to determine the quality of COD and BOD effluents in X Hospital. The type of research used is observational with a descriptive approach. The sampling technique used was purposive sampling, where wastewater samples were taken from two points, namely the inlet and the outlet of the WWTP. Based on the results of the laboratory analysis of the wastewater samples from Hospital X, it can be concluded that the average COD value at the inlet of the WWTP was 64.04 mg/L, while the average COD value at the outlet of the WWTP was 47.90 mg/L, and the average BOD value at the inlet was 12.69 mg/L, while the average BOD value at the outlet was 1.60 mg/L. All of these values are qualified according to the Hospital Activity Liquid Wastewater Quality Standards based on Central Java Province Regional Regulation No. 5 of 2012. It is expected that Hospital X will continue to maintain the wastewater treatment plant.
Keywords: *BOD, COD, hospital waste*

Abstrak
Rumah sakit merupakan salah satu fasilitas pelayanan yang menghasilkan limbah cair dalam jumlah besar dan berkualitas yang memerlukan perhatian khusus karena mengandung bahan berbahaya bagi kesehatan masyarakat dan lingkungan. Penelitian ini bertujuan untuk mengetahui kualitas COD dan BOD air limbah di Rumah Sakit X. Jenis penelitian yang digunakan adalah observasional dengan pendekatan deskriptif. Teknik sampling yang digunakan adalah *purposive sampling*, dengan sampel air limbah yang diambil dari dua titik yaitu inlet dan outlet IPAL. Berdasarkan hasil pemeriksaan laboratorium terhadap sampel air limbah di Rumah Sakit X, dapat disimpulkan bahwa kadar COD pada inlet IPAL rata-rata 64,04 mg/L, sedangkan pada outlet IPAL rata-rata 47,90 mg/L dan kadar BOD pada inlet rata-rata 12,69 mg/L, sedangkan pada outlet rata-rata 1,60 mg/L. Semua nilai ini memenuhi syarat sesuai Standar Baku Mutu Air Limbah Cair Kegiatan Rumah Sakit berdasarkan Peraturan Daerah Provinsi Jawa Tengah Nomor 5 Tahun 2012. Rumah Sakit X diharapkan untuk terus mempertahankan pemeliharaan Instalasi Pengolahan Air Limbah.
Kata Kunci: *BOD, COD, limbah rumah sakit*

1. Introduction

Hospitals are public facilities that are very important and needed by the community. The existence of hospitals has a close relationship with the surrounding community [1], [2]. In the past, hospitals were often built in locations quite far from residential areas and usually close to rivers. This consideration was taken to manage liquid and solid waste so that negative impacts on the population and the environment could be minimized or avoided [3], [4].

According to Law No. 44 of 2009, hospitals are health care institutions that have special characteristics, influenced by the development of health science, technological advances, and socio-economic conditions of the community. Hospitals must be able to improve the quality of services that are better and affordable by the community in order to achieve optimal health status. As a health care institution, hospitals provide a range of services including inpatient, outpatient, and emergency departments to meet individual health needs [4], [5], [6]. Hospitals carry out health service activities to cure patients, hospitals

can also be a place for the spread and transmission of disease to patients, staff, visitors, and local residents who live around the hospital. This is due to the disease-causing agents present in the hospital environment [7], [8], [9].

Hospitals carry out health service activities to cure patients, hospitals can also be a place for the spread and transmission of disease to patients, staff, visitors, and local residents who live around the hospital. This is due to the disease-causing agents present in the hospital environment [10], [11], [12]. To assess the quality of wastewater, laboratory testing is required. The results of the hospital wastewater analysis are then compared with the quality standards set out in the Central Java Provincial Regulation No. 5/2012 on Wastewater Quality Standards for Hospital Activities, covering parameters such as COD and BOD_5 [12], [13], [14], [15].

The research objectives were: 1. knowing the value of COD and BOD5 at the inlet and outlet of the WWTP at Hospital X. 2. Analyzing the COD and BOD5 values at the inlet and outlet of the WWTP at Hospital X to meet the standards set in the Regional Regulation of Central Java Province Number 5 of 2012 concerning Wastewater Quality Standards for hospital activities.

2. Material and Methods

This study used an observational method with a descriptive approach. The sampling technique used was purposive sampling. The equipment used in this research are winkler bottle (Pyrex Schott Duran) 300 mL; glass goblet (Pyrex) 50 mL; Plastic bottle; Pipette volume (Pyrex) 5 mL, 10 mL 50 mL; Piipet measure (Pyrex) 5 mL; Digital buret (Continuous E); Erlenmeyer (Pyrex) 125 mL; Measuring flask (Pyrex) 50 mL, 100 mL, 500 mL and 1000 mL; Incubator (Memmert IN55); Uv-Vis spectrophotometer (Shimadzu type UV 2600); cuvette (QS), Digestion vessel (Iwaki) and heater with holes for tube support (COD Reactor); Magnetic Stirer (Mixer 12 12cm 220v 380) and Analytical Balance (Sartorius type BSA 224S-CW).

The materials used were inlet and outlet liquid waste samples of Hospital X; Digestion Solution with high and low concentrations; Aquadest; 0.024 N Sodium Thiosulfate; 1% amylum/kanji solution; MnSO4 solution (Merck); Sulfuric Acid p. a; Potassium Hydrogen Phthalate p.a; K2Cr2O7 0.25 N; HgSO4(aq) (Merck); NaOH p.a (Merck); KI p.a (Merck); NaN3 p.a (Merck).

Procedure for COD Determination

The vials were washed with phosphate-free detergent and rinsed with clean water. Next, the vials were washed with 1:1 HCI acid solution. Then, the bottle is rinsed three times with analyte-free water and allowed to dry. After drying, the vials were sealed and labeled with “clean container,” and the date of cleaning and the name of the cleaner.

Samples were taken using the Composite Sample method, which is a mixture of several samples collected at the same point at different times. Sampling was carried out at 08.00, 12.00, and 16.00 WIB. Each container was labeled. Test samples are stored by adding concentrated sulfuric acid until they reach a pH below 2, then stored in a refrigerator at a temperature between 4°C ± 2°C. The recommended shelf life is a maximum of 7 daysTest samples are stored by adding concentrated sulfuric acid until they reach a pH below 2, then stored in a refrigerator at a temperature between 4°C ± 2°C. The recommended shelf life is a maximum of 7 days.

KHP mother liquor is prepared using one blank and a minimum of five different concentrations proportionally within the measurement range. The test sample or working solution is taken as much as 2.5 ml and mixed with 1.5 ml of digest solution. Next, 3.5 ml of sulfuric acid reagent solution is added to a tube or ampoule with a size of 16 x 100 mm. The tube is then capped and shaken gently to mix evenly. After that, the tube is placed on a heater that has been heated at 150°C and refluxed for 2 hours.

Calibration Curve Generation

The device was activated and the spectrophotometer was set according to the instructions for use provided for COD testing. The wavelength was adjusted at 420 nm. Then the absorbance of each working solution was measured, recorded and plotted against the COD content.

A calibration curve is made based on the sample data, then the straight line equation is determined. If the linear regression correlation coefficient (r) is less than 0.995, the device is checked and the steps from a) to c) are repeated until the r coefficient value reaches or exceeds 0.995.

The refluxed test sample is then slowly cooled to room temperature to prevent precipitate formation. During the cooling process, the sample is occasionally opened to reduce the gas pressure. The suspension is then allowed to settle, and the portion to be measured should be completely clear. The absorbance of the test sample was measured at a wavelength of 420 nm, and the COD content was

calculated using the linear equation of the calibration curve. The analysis is performed in duplo.

COD value as mg O_2/L:

COD level (mg O_2/L) = C x f

Description:

- C is the COD value of the test sample, expressed in milligrams per liter (mg/L).

- f is the dilution factor.

The results of the test sample absorption readings are entered into the linear regression obtained from the calibration curve. Then the COD value is the result of reading the test sample level from the calibration curve [16], [17], [18].

Procedure for BOD Determination

A Winkler bottle is prepared. The test sample is put into the winkler bottle until it overflows, taking care to avoid air bubbles, then tightly closed so that there are no air bubbles in the bottle. The test sample is tested immediately after the test sample is taken.

The prepared sample was taken. A total of 1 mL of $MnSO_4$ and 1 mL of alkali iodide azide was added with a pipette tip just above the surface of the solution. Then closed immediately and homogenized until a perfect clot formed. The clot was allowed to settle for 5 minutes to 10 minutes. A total of 1 mL of concentrated H_2SO_4 was added, then closed and homogenized until the precipitate dissolved completely. Then pipetted as much as 50 mL, and put into 150 mL erlenmeyer. Titrated with $Na_2S_2O_3$ with amylum/kanji indicator until the exact blue color disappeared.

Samples were put into 2 winkler bottles that had been researched and calibrated for volume. One of the winkler bottles was incubated at 20°C for 5 days, and the other winkler bottle was checked for dissolved oxygen content. For the blank experiment, 2 winkler bottles were prepared, each filled with distilled water. The first bottle was incubated for 5 days at 20°C and the other winkler bottle was checked for oxygen content. The determination of dissolved oxygen content is the same as the DO determination method. Observations were made using the calculation formula for 5 days 20°C BOD as follows:

$$\boldsymbol{BOD_5 = \frac{(A_1 - A_2) - [\frac{B_1 - B_2}{V_B}]Vc}{P}}$$

Description:
BOD_5: BOD_5 value of the test sample (mg/l)

A1 : dissolved oxygen content of the test sample before incubation (0 days) (mg/l)
A2 : dissolved oxygen content of the test sample after incubation (5 days) (mg/l)
B1 : blank dissolved oxygen content before incubation (0 days) (mg/l)
B2 : blank dissolved oxygen content after incubation (5 days) (mg/l)
VB : microbial suspension volume (ml) in DO blank bottle
VC : volume of microbial suspension in the test sample bottle (ml)
P : ratio of test sample volume (V1 per total volume (V2) [19]

3. Results and Discussion

Results of COD Analysis

The results of the COD analysis at the X Hospital WWTP were compared with the quality standards in accordance with the Central Java Regional Regulation No. 5 of 2012 concerning Hospital Wastewater Quality Standards as shown in **Table 1**.

Based on **Table 1**, the average COD value of the inlet sample is 64.04 mg/L and the outlet is 47.90 mg/L, the analysis results meet the quality standards according to the Central Java Regional Regulation No. 5 of 2012 concerning Wastewater Quality Standards in the hospital industry, which is a maximum of 80 mg/l. [15], [17].

Table 1. Results of COD Analysis at the Inlet and Outlet of WWTP Hospital X.

Time	Inlet	Outlet	Quality Standard
08.00 WIB	64.05 mg/L	47.90 mg/L	80 mg/L
12.00 WIB	63.93 mg/L	47.65 mg/L	
16.00 WIB	64.15 mg/L	48.15 mg/L	
The average	**64.04 mg/L**	**47.90 mg/L**	

COD or Chemical Oxygen Demand is the amount of oxygen required to break down all organic matter contained in water. COD testing is used to measure the oxygen value of organic matter in wastewater that can be chemically oxidized with the use of K2Cr2O7 as an oxygen source in an acidic solution. Inlet and outlet samples were tested for COD values by spectrophotometric closed reflux. This closed reflux method is more material-efficient and fast because the principle of the closed reflux method is to accelerate organic reactions by heating without reducing the volume of organic matter [20], [21], [22].

The calibration curve was made by diluting the 500 mg/l KHP mother solution into concentrations of 30 mg/l, 60 mg/l, and 90 mg/l, each of which was put into a 10 ml volumetric flask. After the KHP standard solution is made, 2.5 ml of each standard solution is measured and put into a 16x100 mm digestion vessel tube, then 1.5 ml of digestion solution and 3.5 ml of sulfuric acid reagent solution is added as a catalyst, after which the bottle is closed and homogenized. Furthermore, the solution was refluxed for 2 hours at 150 ° C using a COD reactor, this process functions so that $K_2Cr_2O_7$ oxidizes organic materials perfectly [23], [24].

Finally, after refluxing, the solution was cooled slowly to room temperature to prevent the formation of sediment. In determining the COD content of the inlet and outlet samples, the same treatment was carried out as the determination of the standard solution. The sample solution that has been refluxed and cooled is then measured using a spectrophotometer. The first step is to connect the UV-Vis spectrophotometer cable to the electric current source then turn on the UPS or stabilizer after that the spectrophotometer is turned on, wait until the initialization process is complete, the user display will appear (administrator and password) can be filled in and pressed enter [21], [23].

The spectrophotometer is turned on first for 15-30 minutes before being used for measurements, then turn on the CPU and PC monitor to connect to the software (PC), press F4. Open the UV Probe 2.32 software after which the menu mode display will appear (photometric, spectrum, and kinetics), click the photometric menu, click connect so that the spectrophotometer will automatically connect to the computer. Then click edit, click method, click wavelength type, fill in the wavelength parameter (nm) with the analysis wavelength of 420 nm, click add. Next, the desired measurement type is selected, namely multi point, in the formula selected fixed wavelength because it only uses 1 wavelength. Fill in the WL 1 parameter by selecting the analysis wavelength of 420 nm, then fill in the units parameter with units of measurement, namely mg/l, click next, click next, name the file with the Inlet and Outlet sample names, click finish, click close [17], [21], [23], [24].

Then the standard table is filled in with the name of the standard to be measured, if you want to add the standard name to the next line then press the down arrow on the keyboard, this also applies when naming the sample. After that, a cuvette containing distilled water is inserted into the reference side and the sample side, click autozero to zero the signal. Insert a cuvette containing KHP standard solution to the sample side, click on the standard table then the active display will appear, click read std if there is a question click yes. These steps are repeated until a calibration curve is formed which will appear on the right, to display the line equation, r^2 value, and other parameters right mouse click, click properties and check the list of parameters you want to display [21], [23], [24].

Then the sample is inserted into the cuvette in turn, click the sample table then the active display will appear, click read ink. If the measurement is complete, you can click disconnect, all menus in the UV-Probe are closed, turn off the CPU and monitor, then press the on/off button on the spectrophotometer, turn off the UPS or stabilizer, unplug the spectrophotometer cable from the power source. For quality control, duplo analysis was carried out on inlet and outlet samples to find the % RPD value [21], [22], [24], [25].

Results of BOD_5 Analysis

The analysis results for the BOD_5 parameter at the X Hospital WWTP were compared with the quality standard in accordance with the Central Java Regional Regulation No. 5 of 2012 concerning Hospital Wastewater Quality Standards. as shown in **Table 2**.

Table 2. Results of BOD_5 Analysis at the Inlet and Outlet of WWTP Hospital X

Time	Inlet	Outlet	Quality Standard
08.00 WIB	13.19 mg/l	1.25 mg/l	
12.00 WIB	10.26 mg/l	1.40 mg/l	
16.00 WIB	14.61 mg/l	2.15 mg/l	30 mg/L
The average	**12.69 mg/L**	**1.60 mg/L**	

Based on **Table 2**, the average BOD5 value of the inlet sample is 12.69 mg/L and the outlet is 1.60 mg/L, the analysis results meet the quality standards according to Central Java Regional Regulation No. 5 of 2012 concerning Wastewater Quality Standards in the hospital industry, which is a maximum of 30 mg/l. [19], [25], [26], [27], [28].

BOD or also called Biochemical Oxygen Demand is a property or characteristic that shows the amount of dissolved oxygen needed by microorganisms (bacteria) to break down or decompose organic matter under aerobic conditions. BOD_5 testing requires an incubation period of 5 days because within 5 days microorganisms can decompose organic pollutants by 75% and is also stored at 20 ° C because it is the optimal temperature for microorganisms to multiply. In this BOD_5 test, we did not use microbial seeds added to diluent water nor did we use glutamic acid glucose solution as quality control. The dilution solution used was made from 1 liter of distilled water and added 1 ml of phosphate buffer solution, 1 ml of $MgSO_4$ solution, 1 ml of $CaCl_2$ solution, and 1 ml of FeCl3 solution which was then aerated. After the dilution solution is made, the next step is to test the sample. [21], [22], [29].

Inlet and Outlet samples were measured as much as 30 ml and then put into a 300 ml volume winkler bottle, then added diluent solution that has been made until spilled so that there are no air bubbles that affect oxygen in the sample, then closed and labeled IA_0 and OA_0. Then for the 5-day test, a 300 ml volume winkler bottle was prepared and filled with samples and diluent solution with the same volume, after which the winkler bottle was incubated at 20°C for 5 days. This bottle was labeled as inlet IA_5 and OA_5 [21], [22], [26], [29], [30].

IA_0 and OA_0 bottles are tested in accordance with SNI 6989.72: 2009, namely by adding 1 ml of $MnSO_4$ solution to bind oxygen to $Mn(OH)_2$ which will oxidize into MnO_2 berhidrat and 1 ml of alkaline iodide-azide solution to function as a catalyst, then closed and homogenized, after which a few minutes are waited until the sediment drops and the top of the solution becomes clear. Then the solution was added 1 ml of concentrated H_2SO_4 solution to dissolve the precipitate formed, then closed and shaken until all the precipitate dissolved. After that the solution was measured as much as 50 ml with a measuring flask and put into a 125 ml erlenmeyer, the solution was then titrated with 0.024 N $Na_2S_2O_3$ solution until light yellow, after which the solution was added 1% amylum indicator serves to bind I2 in alkaline iodide azide solution and continued titration again using 0.024 N $Na_2S_2O_3$ solution from dark blue to colorless. The titration results were recorded and calculated as DO0 of the sample. After 5 days the samples in winkler bottles IA5 and OA5 were analyzed in the same way and both samples were calculated as DO5 blanks. [21], [22], [26].

A blank solution is a dilution solution without test samples. This blank solution labeled B_0 was tested together with samples labeled IA_0 and OA_0, while blank solution B_5 was tested together with samples IA_0 and OA_0 that had been incubated at 20°C for 5 days. Testing of blank solutions B_0 and B_5 was the same as testing the samples, where the titration results were recorded and calculated as DO_0 blank and DO_5 blank. The test data of the blank and sample solutions were used to calculate the BOD_5 levels in the inlet and outlet samples. For quality control of the BOD_5 test, measurements on the samples were taken in duplicate to find the %RPD value. [21], [22], [25].

4. Conclusion

The conclusion of the study is that the COD analysis results have an average of 64.04 mg/L at the inlet and 49.9 mgL at the outlet. This value meets the quality standards according to Central Java Regional Regulation No. 5 of 2012 concerning Waste Water Quality Standards in the hospital industry, which is a maximum of 80 mg/L. BOD_5 analysis results have an average of 12.69 mg/L at the inlet and 1.6 mg/L at the outlet. these values meet the quality standards according to Central Java Regional Regulation No. 5 of 2012 concerning Wastewater Quality Standards in the hospital industry, which is a maximum of 30 mg/l.

5. Acknowledgment

Authors thank our colleagues from Universitas Setia Budi and Universitas Serambi Mekkah Indonesia who provided insight and expertise that greatly assisted the research, although they may not agree with all of the interpretations/conclusions of this paper.

6. Abbreviations

COD	*Chemical Oxygen Demand*
%	Percentage
BOD	*Biochemical Oxygen Demand*
RPD	*Relative Percent Difference*
KHP	*Kalium Hidrogen Pthalat*

7. References

[1] M. Apriansyah, A. Agrasadya, A. Sunarto, L. Irawati, and P. N. Kencana, "Pengembangan SDM Rumah Sakit di Tengah Pandemi Covid-19 Pada RS. Medika BSD," *Dedik. PKM*, vol. 2, no. 1, p. 61, 2020, doi: 10.32493/dedikasipkm.v2i1.8493.

[2] H. Christianto and E. D. A. M. Dewi, "Act of Revealing Identity of Patient Confirmed Covid-19 by Hospitals Based on Human Rights and Criminal Law Perspectives," *J. HAM*, vol. 13, no. 1, pp. 131–150, 2022,

[3] dan N. L. U. S. Sukadewi, N. M. T. E., Ni Putu W. A., "Efektivitas Sistem Pengolahan Limbah Cair di Rumah Sakit Bali Med Denpasar Tahun 2020," *Higiene*, vol. 6, no. 3, pp. 113–120, 2020, [Online]. Available: file:///C:/Users/ACER A314/Downloads/garuda2195652.pdf

[4] S. Perancangan *et al.*, "Studi Perancangan Instalasi Pengolahan Air Limbah (IPAL) Domestik di Desa Butuh, Kecamatan Butuh, Kabupaten Purworejo," *Obs. J. Publ. Ilmu Psikol.*, vol. 2, no. 4, pp. 167–178, Aug. 2024, doi: 10.61132/OBSERVASI.V2I4.669.

[5] M. M. Safira, I. Chotimah, and W. Syari, "Hubungan Mutu Pelayanan terhadap Citra di Rumah Sakit X Kota Bogor Tahun 2022," *PROMOTOR*, vol. 6, no. 4, pp. 375–380, Nov. 2023, doi: 10.32832/PRO.V6I4.270.

[6] C. C. Moniaga, P. Prayogo, R. Nansy, and S. Koloay, "Kajian Yuridis Tentang Pertanggungjawaban Rumah Sakit Menurut Doktrin Respondeat Superior," *LEX Adm.*, vol. 12, no. 5, Sep. 2024, Accessed: Oct. 06, 2024. [Online]. Available: https://ejournal.unsrat.ac.id/v3/index.php/administratum/article/view/58018

[7] A. Putri, S. D. Anggraeni, R. Isnarti, and N. N. Khairunnisa, "Studi Komparatif Penanganan Pandemi di Taiwan: SARS, H1N1, dan COVID-19," *Transform. Glob.*, vol. 8, no. 1, pp. 44–66, 2021, doi: 10.21776/ub.jtg.2021.008.01.4.

[8] R. Jannah, E. Nurmardiansyah, and H. Sulistyanto, "Implementation of the Duties and Authorities of the Community Health Center in Managing Medical Waste as a Form of Environmental Health Protection (Case Study at the Wonosalam 2 Health Center, Demak)," *SOEPRA*, vol. 9, no. 1, pp. 137–155, Jun. 2023, doi: 10.24167/sjhk.v9i1.10084.

[9] Monika Fatma Aulianita and Anggraeni Endah Kusumaningrum, "Tanggung Jawab Puskesmas Terhadap Pemantauan Pasien Isolasi Mandiri Dalam Pencegahan Dan Pengendalian Penyebaran Covid-19," *JISPENDIORA J. Ilmu Sos. Pendidik. Dan Hum.*, vol. 1, no. 2, pp. 123–130, May 2023,

[10] A. M. Asrun, L. A. Sihombing, and Y. Nuraeni, "Dampak Pengelolaan Sampah Medis Dihubungkan Dengan Undang-Undang No 36 Tahun 2009 Tentang Kesehatan Dan Undang-Undang No. 32 Tahun 2009 Tentang Perlindungan Dan Pengelolaan Lingkungan Hidup," *PAJOUL (Pakuan Justice J. Law)*, vol. 1, no. 1, pp. 33–46, 2020, [Online]. Available: https://journal.unpak.ac.id/index.php/pajoul/index

[11] I. Gede and P. Yoga, "Perundang-Undangan Rumah Sakit Dalam Pengelolaan Limbah Medis Sebagai Upaya Memantapkan Tanggung Jawab Lingkungan," *J. Ecocentrism*, vol. 3, no. 2, pp. 28–35, Aug. 2023, doi: 10.36733/JECO.V3I2.6636.

[12] Halimah Nur, Budhiartle Arrie, and Fitria, "Kebijakan Rumah Sakit Dalam Sistem Pengelolaan Kesehatan Lingkungan," *J. Adm. Law*, vol. 1, no. 1, pp. 1–15, 2020, doi: 10.22437/MENDAPO.V1I1.8853.

[13] F. Kesehatan Masyarakat, D. Nur Afriliani, and N. Astorina Yunita Dewanti, "Penilaian Proses Pengolahan Limbah Cair di Rumah Sakit Bhayangkara Tk.I R. Said Sukanto Jakarta," *MEDIA Kesehat. Masy. Indones.*, vol. 19, no. 4, pp. 290–296, Aug. 2020, doi: 10.14710/MKMI.19.4.290-296.

[14] S. Khoirunisa, "Pengujian Air Limbah Cair Rumah Sakit Menggunakan Parameter Total Coliform dengan Metode MPM (Most Probable Number) di Balai Riset dan Standardisasi Industri (Baristand) Provinsi Lampung," *J. Sci. Med. Lab.*, 2023, Accessed: Oct. 06, 2024. [Online]. Available: https://rumahjurnal.lppmumpri.ac.id/index.php/JOSMEDLY/article/view/50
[15] R. F. Witjaksono and M. R. Sururi, "Evaluasi Kinerja Instalasi Pengolahan Air Limbah Rumah Sakit X di Jakarta Pusat," *J. Serambi Eng.*, vol. 8, no. 2, Apr. 2023, doi: 10.32672/JSE.V8I2.6018.
[16] P. Pitriani *et al.*, "IPAL Efektivitas Biofilter Dalam Mereduksi Polutan Pada Air Limbah Rumah Sakit Di Kota Palu," *Afiasi J. Kesehat. Masy.*, vol. 7, no. 1, pp. 245–253, Apr. 2022, doi: 10.31943/AFIASI.V7I1.196.
[17] S. Rahmawati, M. Iqbal, N. Y. Hanurawati, and R. Y. Irianto, "Variasi Lama Waktu Elektrokoagulasi dan Filtrasi Terhadap Degradasi Kadar COD pada Limbah Cair Rumah Sakit," *J. Pengendali. Pencemaran Lingkung.*, vol. 6, no. 1, pp. 45–52, Apr. 2024, doi: 10.35970/JPPL.V6I1.2195.
[18] S. G. Prihatino, E. Yuliani, and R. Haribowo, "Studi Evaluasi Instalasi Pengolahan Air Limbah pada Rumah Sakit Umum Daerah Dr. Haryoto Kabupaten Lumajang," *J. Teknol. dan Rekayasa Sumber Daya Air*, vol. 2, no. 2, pp. 156–165, 2022, doi: 10.21776/ub.jtresda.2022.002.02.13.
[19] Fachruddin Azwari, K. Hadidjah, Christine Elia Benedicta, and R. Wahyuni, "Analisis Parameter pH, BOD, TSS, Minyak Dan Lemak Serta Total Coliform Pada Limbah Cair Rumah Sakit Gerbang Sehat Long Bagun Mahakam Ulu," *J. Pengendali. Pencemaran Lingkung.*, vol. 5, no. 1, pp. 45–51, Apr. 2023, doi: 10.35970/jppl.v5i1.1796.
[20] A. B. Surendra, D. Ciptaningtyas, and L. H. Pratopo, "Kinerja Advanced Oxidation Process (Aop) Terintegerasi Dengan Fine Bubble Diffuser Pada Pengolahan Limbah Cair Rumah Potong Ayam," *Hibrida J. Pertanian, Peternakan, Perikan.*, vol. 2, no. 2, pp. 51–60, Sep. 2024, doi: 10.3766/HIBRIDA.V2I2.5982.
[21] N. Fadzry, H. Hidayat, and E. Eniati, "Analisis COD, BOD dan DO pada Instalasi Pengolahan Air Limbah (IPAL) Balai Pengelolaan Infrastruktur Air Limbah dan Air Minum Perkotaan Dinas PUP-ESDM Yogyakarta," *Indones. J. Chem. Res.*, pp. 80–89, Dec. 2020, doi: 10.20885/IJCER.VOL5.ISS2.ART5.
[22] N. Inayah and H. Ni, "Analisis Kualitas BOD (Biological Oxygen Demand) dan COD (Chemical Oxygen Demand) Air Sungai Dhurbugan Batuputih Sumenep," *EVOLUSI J. Math. Sci.*, vol. 6, no. 2, pp. 59–62, Dec. 2022, doi: 10.51673/EVOLUSI.V6I2.1284.
[23] M. A. Naufal and S. Salmahaminati, "Analisis Kadar COD (Chemical Oxygen Demand) Dan TSS (Total Suspended Solid) Pada Air Sungai Di Daerah Semarang," *Indones. J. Chem. Res.*, vol. 9, no. 1, Jul. 2024, doi: 10.20885/IJCR.VOL9.ISS1.ART4.
[24] I. Ramadhan, Y. Rohyami, and R. Ahdiaty, "Verifikasi Metode Uji COD secara Spektrofotometri UV-Vis untuk Low Concentration dan High Concentration," *Indones. J. Chem. Anal.*, vol. 5, no. 1, pp. 52–61, Mar. 2022, doi: 10.20885/IJCA.VOL5.ISS1.ART6.
[25] A. Ayundha, W. Lestari, and E. Erawati, "Analisis Parameter COD Dan BOD Pengolahan Limbah Cair Di RSUD Dr.Moewardi Metode Biofilter Aerob," *Pros. Semin. Nas. Unimus*, vol. 5, no. 0, 2022, Accessed: Oct. 06, 2024. [Online]. Available: https://prosiding.unimus.ac.id/index.php/semnas/article/view/1241
[26] E. Agung Utomo and B. Lekatompessy, "Efisiensi Penurunan Kadar Bod Dan Tss Dengan Bakteri Kultur Em4 Pada Air Limbah Rumah Sakit Dengan Sistem Aerasi," *J. TechLINK*, vol. 6, no. 2, 2022.
[27] S. Kurniajati, M. A. Yusiana, and I. L. Utami, "Literatur Review: Analisis Kualitas Air Limbah Rumah Sakit Menggunakan Indikator Baku Mutu BOD, COD, TSS," *J. Penelit. Keperawatan*, vol. 9, no. 2, pp. 243–251, Aug. 2023, doi: 10.32660/JPK.V9I2.697.
[28] F. Azwari *et al.*, "Analisis Parameter pH, BOD, TSS, Minyak Dan Lemak Serta Total Coliform Pada Limbah Cair Rumah Sakit Gerbang Sehat Long Bagun Mahakam Ulu," *J. Pengendali. Pencemaran Lingkung.*, vol. 5, no. 1, pp. 45–51, Apr. 2023, doi: 10.35970/JPPL.V5I1.1796.
[29] E. Sasiang, S. Maddusa, and O. J. Sumampouw, "Efektivitas Instalasi Pengolahan Air Limbah Berdasarkan Parameter Biological Oxygen Demand, Chemical Oxygen Demand Dan Derajat Keasaman Di Rumah Sakit Umum Pancaran Kasih Manado," 2019.
[30] B. Rahmat and A. Mallongi, "Studi Karakteristik dan Kualitas BOD dan COD Limbah Cair Rumah Sakit Umum Daerah Lanto DG. Pasewang Kabupaten Jeneponto," *J. Nas. Ilmu Kesehat.*, vol. 1, no. 69, pp. 1–16, 2018.