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Evaluation of Hospital Wastewater Quality in Supporting the Achievement of SDG 6: a Case Study in Central Lampung Regency

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Abstract

Achieving Sustainable Development Goal (SDG) 6 on access to clean water and adequate sanitation requires effective wastewater management, including from healthcare facilities such as hospitals. Hospitals have the potential to generate wastewater containing organic and inorganic contaminants, as well as pathogenic microorganisms, which can pose a risk of environmental pollution if not properly treated. This study aims to evaluate the quality of wastewater produced by a hospital in Central Lampung Regency based on the quality standard parameters stipulated in the Regulation of the Minister of Environment and Forestry of the Republic of Indonesia Number 68 of 2016. The parameters tested include pH, Total Suspended Solid (TSS), Chemical Oxygen Demand (COD), Biochemical Oxygen Demand (BOD₅), fatty oil, and total ammonia. The test results showed that the pH value was 6.98; TSS 3.00 mg/L; COD 43.28 mg O₂/L; BOD₅ 1.22 mg/L; fatty oil 0.3 mg/L; and total ammonia 0.191 mg/L. All parameters were well below the maximum quality limits for hospital wastewater. These findings indicate that the hospital's wastewater treatment plant (WWTP) is functioning correctly, resulting in safe wastewater and no potential environmental pollution. This evaluation supports efforts to meet SDG indicator 6.3, which focuses on improving wastewater treatment and reducing water pollution.

Keywords: Central Lampung, Hospital, SDG 6, Wastewater

Introduction

The Sustainable Development Goals (SDGs) are a global agenda established by the United Nations for the period 2015–2030, with SDG 6 focusing on clean water and sanitation. Wastewater treatment is an important component of achieving SDG target 6.3, which emphasizes improving water quality by reducing pollution and increasing the proportion of wastewater that is safely treated (UN-Water, 2021). In this context, wastewater management, including liquid waste from healthcare facilities such as hospitals, is crucial (Janik-karpinska et al., 2023). Inadequate wastewater treatment can increase the risk of environmental pollution, the spread of disease, and negatively impact public health (Shetty et al., 2023).

Hospitals are healthcare units whose core activities include preventive, curative, rehabilitative, and promotional services (Fetene & Bezuidenhout, 2019). These activities can have both positive and negative impacts on society and the environment. A positive impact is improving public health, while a negative impact is the generation of hazardous waste (Khan et al., 2021). Hospitals are among the healthcare facilities that can negatively impact the environment. Hospital operations last 24 hours a day and involve large numbers of people, making them highly susceptible to generating significant amounts of waste (Lee & Lee, 2022).

The World Health Organization (WHO) stated in 2023 that nearly 80% of the waste generated by healthcare centers is general waste, and the remaining 20% is hazardous waste that can be infectious, toxic, or radioactive (Janik-karpinska et al., 2023). Approximately 15% of the waste produced is infectious waste or body tissue waste, 1% is sharps waste, 1% is chemical and pharmaceutical waste, 3% is genotoxic waste, and 1% is radioactive waste. Hospital activities also produce liquid waste that is no less than other types of waste. Hospital liquid waste is wastewater (including fecal waste) generated by hospital activities and may contain microorganisms, toxic chemicals, and radioactive materials that are harmful to health (Nadapdap & Efendy, 2021).

The impact of hospital wastewater on health is significant (Ghali et al., 2023). Therefore, every hospital is required to treat its wastewater to meet the wastewater quality standards stipulated in Regulation of the Minister of Environment and Forestry (LHK) of the Republic of Indonesia Number 68 of 2016 concerning Domestic Wastewater Quality Standards. The impacts on local communities relate to health (Alderwick et al., 2021). Excessive use of chemicals can increase the risk of skin cancer (Matthews et al., 2020). If hospital wastewater contains excessive organic matter, it can cause environmental pollution if not managed properly. Hospital wastewater can contain pathogenic microorganisms, organic compounds, hazardous chemicals, and even pharmaceutical residues (Majumder et al., 2021), so the quality of the treated wastewater must be ensured to comply with national quality standards. It aligns with SDG target 6.3, which encourages countries to reduce water pollution by improving wastewater treatment, reducing the proportion of untreated wastewater, and increasing the recycling and safe reuse of water (Fatimazahra et al., 2023).

To prevent problems caused by domestic and hospital waste, a wastewater treatment plant (WWTP) is needed. The types of treatment in WWTPs include physical, chemical, and biological treatment (Pariante et al., 2022). Biological treatment has several advantages, including easier and cheaper operation, and it can be used for wastewater with a reasonably high Biochemical Oxygen Demand (BOD₅) value. It can reduce suspended solids levels effectively. The quality of wastewater produced by one of the hospitals in Central Lampung Regency is expected to be able to meet the wastewater quality standards stipulated in the Regulation of the Minister of Environment and Forestry (LHK) of the Republic of Indonesia Number 68 of 2016 concerning Domestic Wastewater Quality Standards which include six types of parameters, namely pH, Total Suspended Solid (TSS), Chemical Oxygen Demand (COD), Biochemical Oxygen Demand (BOD₅), fat oil and total ammonia (NH₃-N). By monitoring the results of wastewater treatment by the WWTP, carried out daily and at least once a month, to determine the quality of the wastewater produced.

Method

In this study, a wastewater sample was used as the primary research material. The methods employed in this research included: (1) wastewater sampling, and (2) sample determination to make sure the amount of pH, TSS, COD, BOD₅, fat and total ammonia.

Materials

The materials used in this study were purchased from Merck, Germany. The pH meter (Mettler Toledo) test used buffer solutions of pH 4, 7, and 10. The chemical oxygen demand (COD) test used potassium dichromate (K₂Cr₂O₇), sulfuric acid (H₂SO₄), HgSO₄, 1,10-phenanthroline monohydrate, FeSO₄·7H₂O, and ferrous ammonium sulfate (Fe(NH₄)₂(SO₄)₂·6H₂O). Meanwhile, the biochemical oxygen demand (BOD) test uses potassium dihydrogen phosphate (KH₂PO₄), disodium hydrogen phosphate heptahydrate (Na₂HPO₄·7H₂O), ammonium chloride (NH₄Cl), MgSO₄·7H₂O, calcium chloride (CaCl₂), Ferric (III) Chloride (FeCl₃·6H₂O), diluent water solution (aquadest added with FeCl₃, MgSO₄, CaCl₂ and phosphate buffer solutions), potassium iodide (KI), starch indicators (starch and salicylic acid). Testing ammonia levels uses ammonium chloride (NH₄Cl).

Instrumentation

The instrumentation used in this research are UV-Vis spectra were recorded using a Shimadzu UV-1800 spectrophotometer; Lovibond pH meter; Lovibond COD reactor; Lovibond BOD incubator; Radwag analytical balance; hotplate; waterbath; Memmert oven microwave; desiccator; filter paper; vacuum filtration tools and others laboratory glassware.

Procedure

Wastewater Sampling

Wastewater samples from a wastewater treatment plant (WWTP) at a hospital in Central Lampung were collected using a chemical sampling method. A two-liter sample container was rinsed with the wastewater to be sampled. The wastewater was then filled to the brim and labeled with the code, the date, and the time of sampling.

Sample Determination

The parameters studied included pH, TSS, COD, BOD₅, fat, and ammonia values in hospital wastewater samples (Yolanda & Heriyanti, 2020). The pH test used a potentiometric method. Before the pH determination, the pH meter was calibrated with buffer solutions at pH 4, 7, and 10. Total suspended solids (TSS) were measured using filter paper oven-dried (Mettler UNB 400) at 105°C for 1 hour and stored in a desiccator for 30 minutes (recorded as the initial weight). A total of 700 mL of wastewater was filtered through weighed filter paper and vacuumed using a vacuum pump. After filtration was complete, the filter paper was dried and weighed. The TSS result can be calculated by subtracting the final mass of the filter paper from the initial mass (Kumar & Gupta, 2023). The TSS calculation is shown in equation 1.

$$\text{TSS (mg/L)} = \frac{(W_1 - W_0)}{V} \times 1000 \quad (1)$$

Where:

W₀ = Initial filter media weight (mg)

W₁ = Filter media weight after filtering the sample (mg)

V = Liquid waste sample volume (mL)

COD measurement was conducted using 16 mm × 100 mm digestion vessels that had been washed with 20% H₂SO₄. Two digestion vessels were filled with 2.5 mL of wastewater sample, 1.5 mL of digestion solution, and 3.5 mL of sulfuric acid reagent. At the same time, the other two digestion vessels were filled with the same reagent and distilled water. The four tubes were homogenized and heated in a COD reactor for 2 hours at 150°C. The contents of each solution were transferred into four Erlenmeyer flasks, and 2–3 drops of ferroin indicator were added. The titration process could begin. The titrant used was 0.05 N ferrous ammonium sulfate, with ferroin as the indicator. Ferrous ammonium sulfate was prepared by dissolving 19.6 g of Fe(NH₄)₂(SO₄)₂·6H₂O with 300 mL of distilled water in a 1000 mL volumetric flask. Then, 20 mL of concentrated H₂SO₄ was added, and distilled water was added to the mark. The ferroin indicator was prepared by mixing 1.485 g of 1,10-phenanthroline monohydrate and 0.695 g of FeSO₄·7H₂O, then dissolving each in distilled water in a 100 mL volumetric flask. The endpoint of the titration was reached when the solution color changed; the volume of titrant used for each analyte was then recorded, and the COD was calculated using equation 2.

$$\text{COD (mg O}_2\text{/L)} = \frac{(A - B) \times N \times 8000}{\text{mL sample}} \quad (2)$$

Where :

A = Volume of titrant used for blank titration (mL)

B = Volume of titrant used for sample titration (mL)

N = Normality of ferrous ammonium sulfate/FAS titrant solution

The blank solution was made by combining 1 mL each of FeCl₃, MgSO₄, CaCl₂, and phosphate buffer solutions, and 2 mL of microbial seed solution (BOD seed), and diluting to a 1000 mL volumetric flask. Four Winkler bottles were prepared for blank analysis. The blank solution was divided into two bottles for blank DO₀ analysis and two for blank DO₅ analysis. The DO₅ Winkler bottles were incubated for 5 days at 20 °C in an incubator. A total of 2 mL of liquid waste sample was put into a 500 mL volumetric flask, then diluted with diluent solution to the limit mark. After that, the solution was placed in four labeled Winkler bottles: two for DO₀ testing and two for DO₅ testing. Bottles labeled DO₅ were stored and incubated for 5 days at 20°C, while bottles labeled DO₀ were immediately tested by adding 1 mL of MnSO₄ and KI solutions each, then homogenized and waited for at least 10 minutes until a precipitate formed. After the precipitate formed, 1 mL of concentrated H₂SO₄ was added to the DO₀ bottle, and the mixture was homogenized until the precipitate dissolved completely. Next, the titration was carried out by pipetting 50 mL of the solution into the DO₀ Winkler bottle and transferring it to an erlenmeyer flask. The titration was carried out using a standard Na₂S₂O₃ solution as the titrant until the solution in the Erlenmeyer flask changed from golden yellow to light yellow. After the color change, 2–3 drops of starch indicator were added to the analyte solution until the solution turned blackish blue. Next, the solution was titrated again until the solution turned clear, and the volume of titrant used was measured and recorded. The two Winkler bottles labeled DO₀, containing blank solutions, were also titrated on the same day, using the same procedure as for the DO₀ sample test. After incubation for 5 days, two bottles labeled DO₅ containing samples and two bottles labeled DO₅ containing blanks were ready for testing, using the same steps as for the DO₀ samples. Dissolved oxygen values can be measured using a DO meter or analytically using the Winkler method and iodometric titration, with calculations based on mathematical equations (Wei et al., 2019).

$$\text{Dissolved oxygen (mg/L)} = \frac{V \times N \times 8000 \times F}{\text{Analyte volume (mL)}} \quad (3)$$

Where:

V = Volume of Na₂S₂O₃ (titrant) (mL)

N = Normality of Na₂S₂O₃ titrant

F = Correction Factor

High BOD₅ values are caused by the high organic matter content in the form of vegetable and fruit residues, oils, and leaves, which can produce unpleasant odors due to the decomposition process of these materials (Mustafa & Maryam, 2023). The following is the BOD₅ calculation formula written in SNI 6989.72-2009.

$$\text{BOD}_5 \text{ (mg/L)} = \frac{(A_1 - A_2) - \left(\frac{B_1 - B_2}{V_B}\right)V_C}{P} \quad (4)$$

Where:

A₁ = Dissolved oxygen content of the test sample before 5 days of incubation (mg/L)

A₂ = Dissolved oxygen content of the test sample after 5 days of incubation (mg/L)

B₁ = Dissolved oxygen content of the blank before 5 days of incubation (mg/L)

B₂ = Dissolved oxygen content of the blank after 5 days of incubation (mg/L)

V_b = Volume of microbial suspension (mL) in the blank bottle

V_c = Volume of microbial suspension (mL) in the test sample bottle

P = Ratio of test sample volume to total volume

The fat oil content was determined by taking 1000 mL of the waste sample and dividing it into two 500 mL separating funnels. Each was treated with 1 mL of concentrated H₂SO₄, 20 mL of n-hexane, homogenized, and left for 10 minutes to allow two layers to form. After the two layers formed, the water phase was below, and the oil phase was above. The water phase was collected in a beaker, and the oil phase was collected in an erlenmeyer flask. The extraction process was carried out twice: the collected water phase was returned to the separating funnel, 10 mL of n-hexane was added, the mixture was homogenized again, and the oil phase was collected. Next, the oil phase obtained was mixed into the same centrifuge tube and centrifuged at 24 rpm × 100 for 10 minutes. The oil phase is transferred into a beaker whose initial mass is known (the mass of the empty beaker), then placed in a water bath at 85°C to separate the oil species from the n-hexane solvent, which previously dissolved the oil species in the test sample. After heating and ensuring it is clean of n-hexane solvent, the beaker is cooled in a desiccator for 15-30 minutes, then weighed and recorded as the final mass (the mass of the beaker after adding oil).

Ammonia analysis using the spectrophotometric phenate method (SNI 06-6989.30-2025). Amount 3.819 g of ammonium chloride (dried at 100°C) was placed in a 1000 mL volumetric flask, diluted to the limit mark with distilled water, and homogenized. 10 mL of a 1000 ppm ammonia stock solution was added, diluted to 10 ppm, and diluted to 100 mL. After that, the ammonia working solution was prepared by pipetting 0.0 mL, 0.5 mL, 1.0 mL, 1.5 mL, 2.5 mL, and 3 mL of 10 ppm ammonia standard solution, and each was placed into a 100 mL volumetric flask. Then distilled water was added to the limit mark to obtain a series of standard ammonia solutions at 0.0 ppm, 0.1 ppm, 0.2 ppm, 0.3 ppm, 0.5 ppm, and 0.6 ppm. 25 mL of the standard solution was prepared and placed into 100 mL Erlenmeyer flasks. To each Erlenmeyer flask, 1 mL of phenol solution, 1 mL of sodium nitroprusside solution, and 2.5 mL of oxidizing solution were added. The solution was incubated for 1 hour, then placed in a cuvette, and its absorbance was measured at 640 nm.

Result and Discussion

Water suitable for living things has a pH range of 6.5–9.0 (Tarigan & Sundari, 2020). If the pH is below this range, the water will be acidic; if it is above this range, the water will be alkaline. pH is an important parameter in wastewater treatment because extreme acidic or alkaline conditions can affect biological processes involved in organic matter degradation. (Majumder et al., 2021). Based on pH meter tests (Table 1), the liquid waste had pH values of 6.81 and 7.15, yielding an average pH of 6.98. These results are still within the safe pH range for hospital liquid waste, as stipulated by the Central Government through the Regulation of the Minister of Environment and Forestry of the Republic of Indonesia Number 68 of 2016, namely 6-9. Thus, the liquid waste sample has a pH within safe environmental limits.

Total Suspended Solids are suspended materials that cause turbidity in water. Turbidity occurs due to the presence of floating colloidal particles and suspended matter, broken down into smaller sizes and carried by microbes, organic matter, microorganisms, mud, soil, and other floating objects. Excessive suspended materials negatively impact water quality by reducing the intensity of sunlight penetrating the water body, thereby causing growth disorders in organisms (Stephen et al., 2023). The TSS result was 3.0 mg/L (Table 1). This result is still far below the maximum TSS limit of 30 mg/L set by the Central Government through the Regulation of the Minister of Environment and Forestry of the Republic of Indonesia Number 68 of 2016. Thus, the liquid waste has a TSS content that remains within safe environmental limits.

COD is the amount of oxygen in units of mg/L or ppm needed to decompose organic substances chemically. COD measures the level of dissolved oxygen that can chemically oxidize organic substances in wastewater using dichromate in an acidic environment. An increase in COD values indicates a low dissolved oxygen content in the water (Li et al., 2018). COD testing is performed to determine the amount of oxygen required so that the waste can be oxidized through a chemical reaction. In this case, the method used is titrimetry. Waste samples containing organic substances will be oxidized with potassium dichromate ($K_2Cr_2O_7$), which serves as an oxidant (Li et al., 2018). The chemical reaction that occurs is based on equation 5. Based on the test results, the COD level in the liquid waste was 51.936 mg O_2 /L for simplo testing and 34.624 mg O_2 /L for duplo testing, resulting in an average COD level of 43.28 mg O_2 /L (Table 1). This result is still below the maximum COD limit of 100 mg O_2 /L set by the Central Government through the Minister of Environment and Forestry Regulation Number 68 of 2016. Thus, liquid waste sample has a COD level that remains within safe environmental limits.

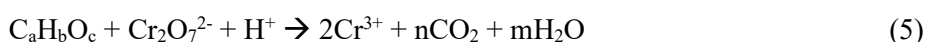


Table 1. Test result of V-45 liquid waste sample

Parameter	Test Result	Limit Standard
pH	6,98	6 – 9
TSS (mg/L)	3	30
COD (mg O_2 /L)	43,28	100
BOD ₅ (mg/L)	1,227	30
Oil and fat (mg/L)	0,3	5
Total ammonia (mg/L)	0,191	10

BOD parameter is carried out to determine the amount of oxygen (ppm or mg/L) needed to decompose organic substances by bacteria in the liquid waste sample. In determining the BOD value based on the dissolved oxygen examination, the dilution factor is first determined. The dilution used in the BOD measurement is based on the previously obtained COD value. In determining wastewater quality, dissolved oxygen is an important parameter because it participates in the oxidation and reduction of organic and inorganic materials and helps reduce pollution loads in water, naturally and aerobically, which is carried out to purify industrial and household wastewater (Bendicho & Lavilla, 2019). Based on the test results (Table 1), the BOD₅ level of the liquid waste sample was 1.227 mg O_2 /L. This result is still far below the maximum BOD₅ limit of 30 mg/L set by the Central Government

through the Minister of Environment and Forestry Regulation Number 68 of 2016. Thus, V-45 liquid waste has a BOD₅ level that remains safe for the environment.

Oil and fat are insoluble in water. Their presence in wastewater can cause water pollution, so their concentration must be limited. Oil has a lower density than water, so it forms a thin film on the water's surface. This condition can reduce the dissolved oxygen content in the water by inhibiting the fixation of free oxygen. Oil and fat are organic materials that are fixed and difficult for bacteria to decompose. The liquid waste sample was analyzed using the gravimetric method to analyze oil and fat content. The principle of the oil and fat test is liquid-liquid extraction, which is based on the difference in the final mass of a beaker containing oil and fat extracts compared to the initial mass of a beaker containing no other substances. The oil and fat test results for the wastewater sample showed a concentration of 0.3 mg/L (Table 1). This result is still well below the maximum oil and fat content limit of 5 mg/L set by the Central Government through the Minister of Environment and Forestry of the Republic of Indonesia Regulation Number 68 of 2016. Therefore, the V-45 liquid waste contains oil and fat within environmentally safe limits.

Ammonia levels in liquid waste samples are determined using a UV-Vis spectrophotometer with the phenate method (SNI 06-6989.30-2005). According to Murti et al. (2014), the principle of this ammonia level test is that ammonia molecules in water react with sodium hypochlorite to form chloramine compounds (NH₂Cl). Next, chloramine reacts with phenolate reagents to form intermediate compounds, namely monochlorquinone. Monochlorquinone reacts with the remaining phenolate reagents to form blue indophenol products that can be detected by UV-Vis spectrophotometry (Utomo et al., 2023). Sodium nitroprusside acts as a catalyst in the indophenol formation reaction (Figure 1).

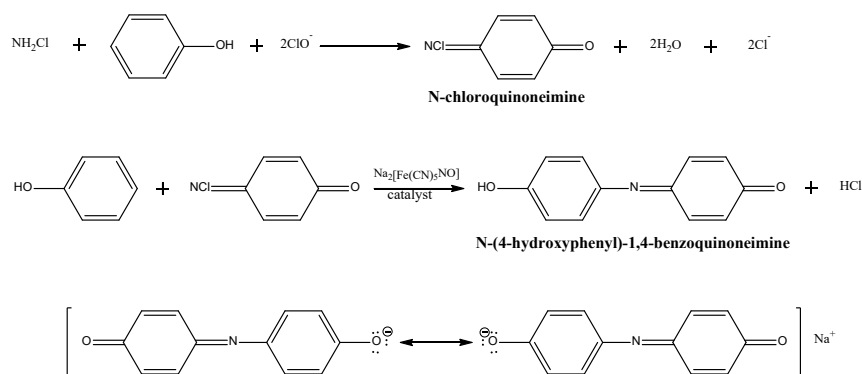


Fig 1. Scheme of the Formation of the Indophenol Blue Complex (Sasongko et al., 2018)

Ammonia is an important nitrogen-containing pollutant in wastewater, and its concentration is therefore included among the parameters used to evaluate wastewater quality.

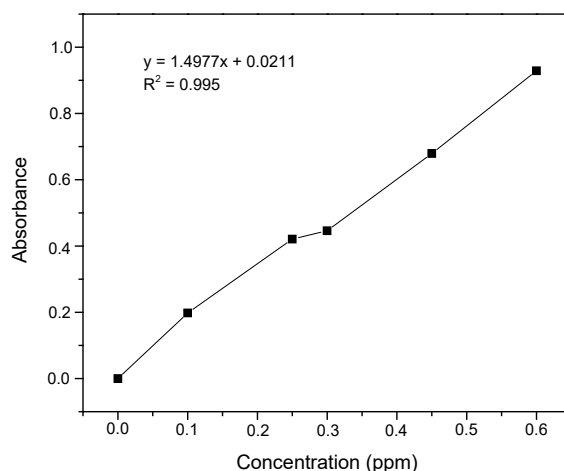


Fig 2. Calibration Curve of Ammonia Standard Solution

Based on the results of the liquid waste quality test, the ammonia content was 0.191 mg/L using the calibration standard curve method (Figure 2). The calibration curve showed a strong linear relationship, with an R^2 value of 0,995. The ammonia content obtained was still well below the maximum limit for total ammonia, set by the Central Government through the Regulation of the Minister of Environment and Forestry of the Republic of Indonesia Number 68 of 2016, at 10 mg/L. Thus, the liquid waste has a total ammonia content that remains within safe environmental limits.

Conclusion

Based on the results of the wastewater quality evaluation from one of the hospitals in Central Lampung Regency, all test parameters including pH, Total Suspended Solid (TSS), Chemical Oxygen Demand (COD), Biochemical Oxygen Demand (BOD_5), fatty oil, and total ammonia showed values that were still below the maximum limits stipulated in the Regulation of the Minister of Environment and Forestry of the Republic of Indonesia Number 68 of 2016 concerning Domestic Wastewater Quality Standards. The pH value of 6.98, TSS 3.00 mg/L, COD 43.28 mg O_2 /L, BOD_5 1.22 mg/L, fatty oil 0.3 mg/L, and total ammonia 0.191 mg/L indicated that the wastewater treatment process through the hospital's wastewater treatment plant (WWTP) had been running effectively. Thus, the liquid waste produced does not pose an environmental pollution risk and meets the requirements for safe wastewater quality, while supporting efforts to achieve SDG 6 targets, particularly in wastewater management and the protection of aquatic environmental quality.

Reference

- Alderwick, H., Hutchings, A., Briggs, A., & Mays, N. (2021). *The impacts of collaboration between local health care and non-health care organizations and factors shaping how they work: a systematic review of reviews*. 1–17.
- Bendicho, C., & Lavilla, I. (2005). WATER ANALYSIS | Sewage. *Encyclopedia of Analytical Science (2nd edition)*. 300-307. <https://doi.org/10.1016/B0-12-369397-7/00113-8>
- Badan Standardisasi Nasional. (2005). SNI 06-6989.30-2005: Cara Uji Kadar Amonia Dengan Spektrofotometer Secara Fenat.
- Badan Standardisasi Nasional. (2009). SNI 6989.72:2009: Air dan air limbah bagian 72: Cara uji kebutuhan oksigen biokimia (Biochemical Oxygen Demand/ BOD).
- Fatimazahra, S., Latifa, M., Laila, S., & Monsif, K. (2023). Review of hospital effluents: special emphasis on characterization, impact, and treatment of pollutants and antibiotic resistance. *Environmental monitoring and assessment*, 195(3), 393. <https://doi.org/10.1007/s10661-023-11002-5>

- Fetene, N., & Bezuidenhout, M. C. (2019). *Integrating promotive , preventive , and curative health care services at hospitals and health centers in Addis Ababa , Ethiopia*. 243–255.
- Ghali, H., Cheikh, A. B., Bhiri, S., Bouzgarrou, L., Rejeb, M. B., Gargouri, I., & Latiri, H. S. (2023). *Health and Environmental Impact of Hospital Wastes : Systematic Review*. <https://doi.org/10.1159/000529432>
- Janik-karpinska, E., Brancaloni, R., Niemcewicz, M., Wojtas, W., Foco, M., Podogrocki, M., & Bijak, M. (2023). *Healthcare Waste — A Serious Problem for Global Health*. 1–14.
- Khan, M. T., Shah, I. A., Ihsanullah, I., Naushad, M., Ali, S., Shah, S. H. A., & Mohammad, A. W. (2021). Hospital wastewater as a source of environmental contamination: An overview of management practices, environmental risks, and treatment processes. *Journal of Water Process Engineering*, 41, 101990.
- Kumar, M., & Gupta, A. (2023). *Predicting Total Suspended Solids from Turbidity for different types of Soil Particles*. 7(12), 30–39. <https://doi.org/10.31080/ASAG.2023.07.1323>
- Lee, S. M., & Lee, D. (2022). *Green Healthcare*.
- Li, J., Luo, G., He, L., Xu, J., & Lyu, J. (2018). Analytical Approaches for Determining Chemical Oxygen Demand in Water Bodies: A Review. *Critical reviews in analytical chemistry*, 48(1), 47–65. <https://doi.org/10.1080/10408347.2017.1370670>
- Majumder, A., Gupta, A. K., Ghosal, P. S., & Varma, M. (2021). A review on hospital wastewater treatment: A special emphasis on occurrence and removal of pharmaceutically active compounds, resistant microorganisms, and SARS-CoV-2. *Journal of environmental chemical engineering*, 9(2), 104812. <https://doi.org/10.1016/j.jece.2020.104812>
- Matthews, N. H., Fitch, K., Li, W., Morris, J. S., David, C., Qureshi, A. A., Cho, E., Israel, B., Medical, D., Memorial, H. S. T., Hospital, V., Unit, C. C., & Hospital, R. I. (2020). *HHS Public Access*. <https://doi.org/10.1158/1055-9965.EPI-18-0286.Exposure>
- Mustafa, K., & Maryam, D. (2023). *Advances in Bioremediation : A Prospective Approach for Green Food Waste Management*. 4(1), 48–67.
- Nadapdap, T. P., & Efendy, I. (2021). *Analysis of Solid Medical Waste Management at Uptd Regional General Hospital Datu Beru , Central Aceh Regency*. 1(2), 48–61.
- Pariente, M. I., Segura, Y., Álvarez-Torrellas, S., Casas, J. A., De Pedro, Z. M., Diaz, E., ... & Martínez, F. (2022). Critical review of technologies for the on-site treatment of hospital wastewater: From conventional to combined advanced processes. *Journal of Environmental Management*, 320, 115769.
- Sasongko, A. (2018). Ammonia Determination In Bottled Water Using Spectrophotometer : Comparison Between Nessler And Berthelot Methods. *JST (Jurnal Sains Dan Teknologi)*, 7(1), 126–134. <https://doi.org/10.23887/jstundiksha.v7i1.13009>
- Shetty, S. S., Deepthi, D., Harshitha, S., Sonkusare, S., Naik, P. B., N, S. K., & Madhyastha, H. (2023). Heliyon Environmental pollutants and their effects on human health. *Heliyon*, 9(9), e19496. <https://doi.org/10.1016/j.heliyon.2023.e19496>
- Stephen, H., James, D., & Ahmad, S. (2023). *Measurement of Total Dissolved Solids and Total Suspended Solids in Water Systems : A Review of the Issues , Conventional , and Remote Sensing Techniques*. 1–43.
- Tarigan, I. L., & Sundari, V. (2020). *Physical , chemical , and biological analysis of drinking water quality in Tulungagung regency East Java*. 2(1), 23–30.
- UN-Water. (2021). *Progress on wastewater treatment – 2021 update*. United Nations.
- Utomo, W. P., Wu, H., & Ng, Y. H. (2023). Quantification Methodology of Ammonia Produced from Electrocatalytic and Photocatalytic Nitrogen/Nitrate Reduction. *Energies*, 16(1). <https://doi.org/10.3390/en16010027>
- Wei, Y., Jiao, Y., An, D., Li, D., Li, W., & Wei, Q. (2019). Review of dissolved oxygen detection technology: From laboratory analysis to online intelligent detection. *Sensors (Switzerland)*, 19(18). <https://doi.org/10.3390/s19183995>
- Yolanda, V. C., & Heriyanti, A. P. (2020). *Wastewater Quality Characteristics Test in Domestic Wastewater Treatment Plant Dinas Lingkungan Hidup Kota Semarang*. 44–52.