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The effect of Electrode Type Differences on BOD and COD Reduction in Tofu Wastewater Treatment

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ABSTRACT

Research has been conducted aimed at testing the results of tofu liquid waste samples on the Biochemical Oxygen Demand (BOD) and Chemical Oxygen Demand (COD) parameters before and after the electrocoagulation process using Al, Cu, and Zn electrodes. This study used tofu liquid waste from Jl. Pasar V Helvetia. The BOD test results before electrocoagulation were 816 mg/L. The BOD test results after electrocoagulation with Al electrodes were 112 mg/L, Cu electrodes were 55 mg/L, and Zn electrodes were 115.2 mg/L. The COD level test results before electrocoagulation were 2696 mg/L. The COD level test results after electrocoagulation with Al electrodes were 95 mg/L, Cu electrodes were 62 mg/L, and Zn electrodes were 105 mg/L. From the electrode variations, the best results were obtained for testing the BOD and COD levels of tofu liquid waste on the Cu electrode.

Keywords: BOD, COD, Electrocoagulation, Electrode

ABSTRAK

Telah dilakukan penelitian yang bertujuan untuk hasil uji sampel limbah cair tahu terhadap parameter *Biochemical Oxygen Demand* (BOD) dan *Chemical Oxygen Demand* (COD) sebelum dan sesudah proses elektrokoagulasi menggunakan elektroda Al, Cu, dan Zn. Penelitian ini menggunakan limbah cair tahu Jl. Pasar V Helvetia. Hasil uji BOD sebelum elektrokoagulasi sebesar 816 mg/L. Hasil uji BOD setelah elektrokoagulasi dengan elektroda Al sebesar 112 mg/L, elektroda Cu sebesar 55 mg/L, dan elektroda Zn sebesar 115,2 mg/L. Hasil uji kadar COD sebelum elektrokoagulasi sebesar 2696 mg/L. Hasil uji kadar COD setelah elektrokoagulasi dengan elektroda Al sebesar 95 mg/L, elektroda Cu sebesar 62 mg/L, dan elektroda Zn sebesar 105 mg/L. Dari variasi elektroda tersebut diperoleh hasil terbaik untuk pengujian kadar BOD dan COD limbah cair tahu pada elektroda Cu.

Kata kunci: BOD, COD, Elektroda, Elektrokoagulasi

1. Introduction

The tofu industry in Indonesia is largely dominated by small-scale businesses, which often do not have access to adequate wastewater treatment infrastructure. Consequently, liquid waste from tofu production is frequently released directly into nearby water bodies without any treatment. This wastewater is rich in organic compounds, particularly proteins and amino acids, which can promote rapid microbial growth [1]. During the production process, the tofu industry generates two types of waste: solid and liquid. These wastes can negatively affect water quality due to the increased presence of organic matter, which can also disrupt aquatic

life [2]. Tofu liquid waste, with its high organic content and elevated BOD and COD levels, can significantly compromise the ecological capacity of water bodies if discharged without proper treatment [3].

The tofu industry is a significant source of organic waste. In many cases, liquid waste from tofu production is disposed of in poorly maintained landfills or directly into rivers, leading to environmental pollution and unpleasant odors. This waste is frequently discharged without undergoing any treatment, which worsens the environmental impact. Without proper management, the properties of tofu liquid waste can surpass the threshold limits established by environmental quality standards [4]. As a result, the tofu liquid waste contains high concentrations of BOD (816 mg/L) and COD (2696 mg/L). Based on the Indonesian Minister of Environment Regulation No. 5 of 2014 regarding standards for industrial wastewater discharge, the permitted maximum levels are 150 mg/L for BOD and 300 mg/L for COD [5]. Thus, discharging tofu industry liquid waste without prior treatment can lead to foul odors, contamination of water sources, and the potential spread of diseases. To avoid these negative effects, it is necessary to treat the wastewater, one effective method being electrocoagulation [6].

Electrocoagulation is a wastewater treatment method that uses an electric current to separate suspended particles and pollutants from the air. This method begins by passing an electric current through electrodes submerged in a liquid. As the current flows, positive ions (cations) are released from the anode, while negative ions (anions) are released from the cathode. These ions then interact with pollutants in the air, forming larger flocs, which can then settle [7]. Electrocoagulation is designed to remove suspended particles from wastewater by neutralizing the electrostatic forces that prevent them from settling. This method offers several advantages, including the production of minimal sludge, the formation of relatively large flocs, lower water content in the sludge, greater stability, and ease of filtration [8]. Doing electrolysis for a longer time can help release more metal ions, but if it goes on too long, it might not be as effective because of saturation or the metal ions dissolving again [9].

This study employs the electrocoagulation method, a widely used electrochemical technique in wastewater treatment. The process involves immersing metal electrodes into the wastewater and applying an electric current. As the reaction takes place, flocculants are generated, which help in binding and removing suspended particles and contaminants from the liquid waste [10].

Aluminum (Al), copper (Cu), and zinc (Zn) are utilized as electrodes in the electrocoagulation process because of their capacity to generate flocs that efficiently bind and settle contaminants present in the wastewater [11]. Hence, an effective and environmentally friendly treatment method for tofu wastewater is essential to minimize its negative effects. The treatment approach should take into account key factors such as efficiency, cost-effectiveness, and potential environmental impact [12].

This research aims to ensure that tofu wastewater complies with the quality standards set by the Indonesian Ministry of Environment Regulation No. 5 of 2014. Before the wastewater can be reused or safely released into the environment, it must be tested to determine the extent of pollutant removal and assess the overall improvement in water quality [13]. Accordingly, BOD and COD measurements were carried out on tofu liquid waste to determine the treatment method's efficiency, with this study emphasizing the use of electrocoagulation for reducing these pollutant levels.

2. Method

This experiment was conducted at the Basic Physics Laboratory of UINSU Medan located at Jl. Golf Course, Medan Tuntungan and at the Medan Environmental Health Engineering and Disease Control Center (BTKLPP) located at Jl. K.H. Wahid Hasyim No. 15, Medan 20154. Tofu liquid waste came from Jl. Pasar V Helvetia, Medan Deli District, Deli Serdang Regency. The electrode variations used were aluminum, copper, and zinc, which in this study were 10 cm long and 0.3 cm in diameter. The tools used in this study were Whattman 42 filter paper, 1000 mL beaker, stopwatch, multimeter, connecting cable, and electrical adapter. This study was divided into two stages:

First, tofu liquid waste samples must be tested before the electrocoagulation procedure begins. Tofu liquid waste samples were taken first and then analyzed for BOD and COD testing methods according to tofu liquid waste quality standards, comparisons were made with tofu wastewater quality standards stipulated in Regulation No. 5 of 2014 which has been stipulated by the Indonesian Ministry of Environment.

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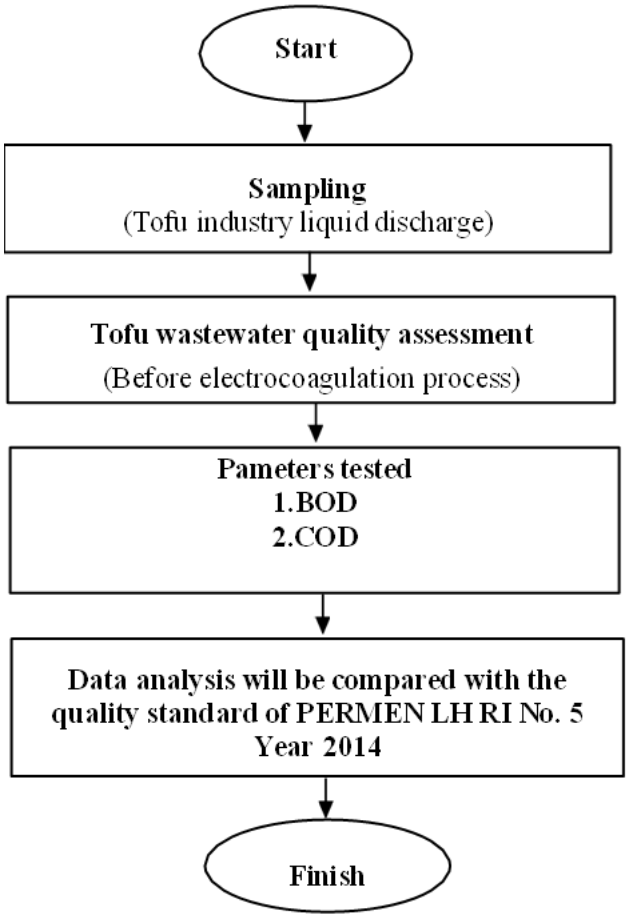

Figure 1. Flowchart of tofu liquid waste quality testing stage before electrocoagulation process.

Second, tofu liquid waste sample after electrocoagulation process Tofu liquid waste sample was taken at Jl. Pasar V Helvetia, Medan Deli District, Deli Serdang Regency, North Sumatra. The tofu liquid waste sample was put into a 1000 mL beaker glass with a distance of 2 cm between the cylindrical electrodes (aluminum, copper, and zinc) mounted on the stand then the wire was connected to the cylindrical electrodes (aluminum, copper, and zinc) to the power source. The voltage was set to 12 volts, with a time of 60 minutes. Then the results were tested using the BOD and COD methods. The results were then compared with the tofu liquid waste quality standards stipulated in the Ministry of Environment Regulation No. 5 of 2014.

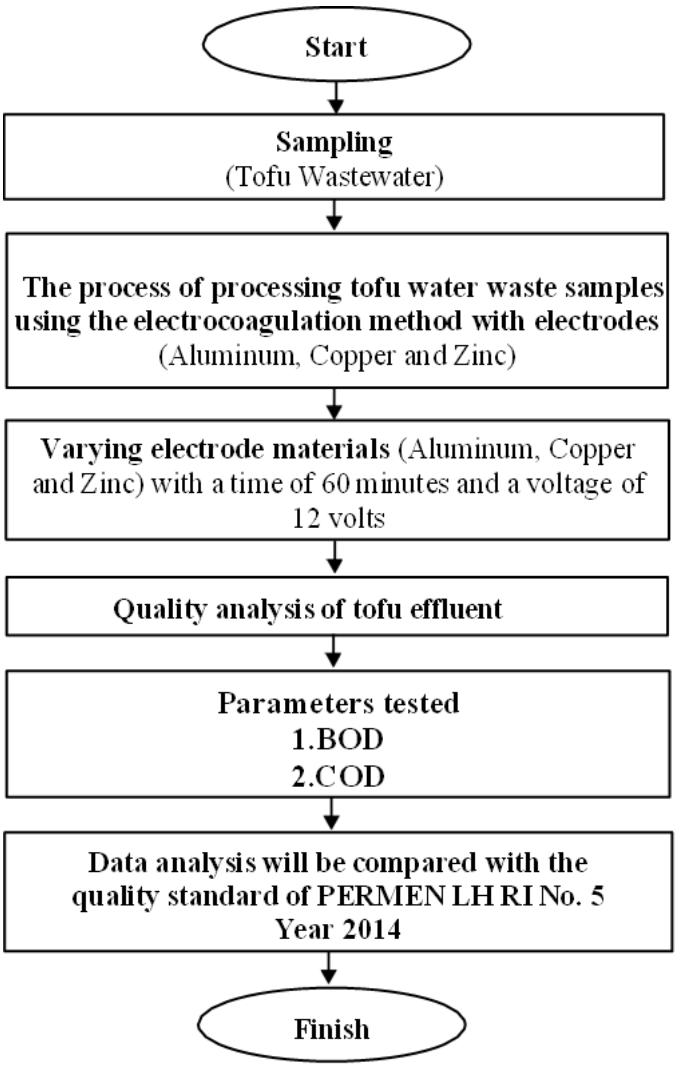

Figure 2. Flowchart of tofu liquid waste quality testing stage after electrocoagulation process.

For the electrocoagulation process equipment circuit can be seen in the Figure 3.

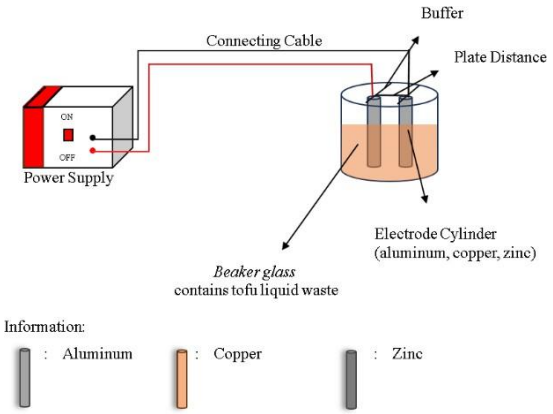

Figure 3. Electrocoagulation process equipment circuit.

3. Result and Discussion

This study was carried out using an experimental approach, with tofu liquid waste samples serving as the primary test material. Tofu liquid waste samples were tested before and after electrocoagulation. Good waste must meet the quality standards that have been set so as not to pollute the environment. The parameters tested were BOD and COD, in accordance with the tofu liquid waste quality standards specified in PERMEN LH RI Number 5 of 2014.

3.1. Tofu Liquid Waste Before and After Electrocoagulation

Prior to the electrocoagulation process, tofu liquid waste was first tested to determine its BOD and COD levels. The sample data of the tofu wastewater before treatment is presented in Table 1.

Table 1. Tofu liquid waste sample data before electrocoagulation process.

Test Parameter	Result	Tofu Wastewater Quality Requirements Based on PERMEN LH RI No. 5 of 2014
BOD	816 mg/L	150 mg/L
COD	2696 mg/L	300 mg/L

Table 1 shows the test results of tofu liquid waste before undergoing the electrocoagulation process, assessed based on the standards set by the Indonesian Ministry of Environment Regulation (PERMEN LH RI) No. 5 of 2014. The analysis indicated that the BOD level was 816 mg/L and the COD level was 2696 mg/L. These values significantly exceed the allowable limits of 150 mg/L for BOD and 300 mg/L for COD, demonstrating that the wastewater fails to meet the established environmental quality standards.

According to the research conducted, Table 2 presents the outcomes of treating tofu liquid waste through electrocoagulation using different electrode materials, namely aluminum, copper, and zinc.

Table 2. Data of tofu liquid waste samples after the electrocoagulation process.

Parameter	Result			Tofu Wastewater Quality Requirements Based on PERMEN LH RI No. 5 of 2014
	Aluminum	Copper	Zinc	
BOD	112 mg/L	55 mg/L	115.2 mg/L	150 mg/L
COD	95 mg/L	62 mg/L	105 mg/L	300 mg/L

Table 2 shows that the tofu liquid waste treated using the electrocoagulation method with aluminum, copper, and zinc electrodes complies with the quality standards outlined in the Indonesian Ministry of Environment Regulation No. 5 of 2014. The treatment with aluminum electrodes resulted in BOD and COD levels of 112 mg/L and 95 mg/L, respectively. The copper electrodes achieved the highest reduction, with BOD dropping to 55 mg/L and COD to 62 mg/L. Meanwhile, the zinc electrodes yielded BOD and COD values of 115.2 mg/L and 105 mg/L, respectively. All of these values meet the acceptable limits for tofu wastewater quality.

3.2. Effect of Electrode Variation on BOD and COD in Electrocoagulation Process

The BOD test provides insight into the ability of electrocoagulation to decrease organic load in tofu liquid waste. A more substantial decline in BOD values after treatment signifies better performance of the process in reducing organic pollutants. This study involved BOD testing with different electrode materials aluminum, copper, and zinc. The test results are displayed in Figure 4.

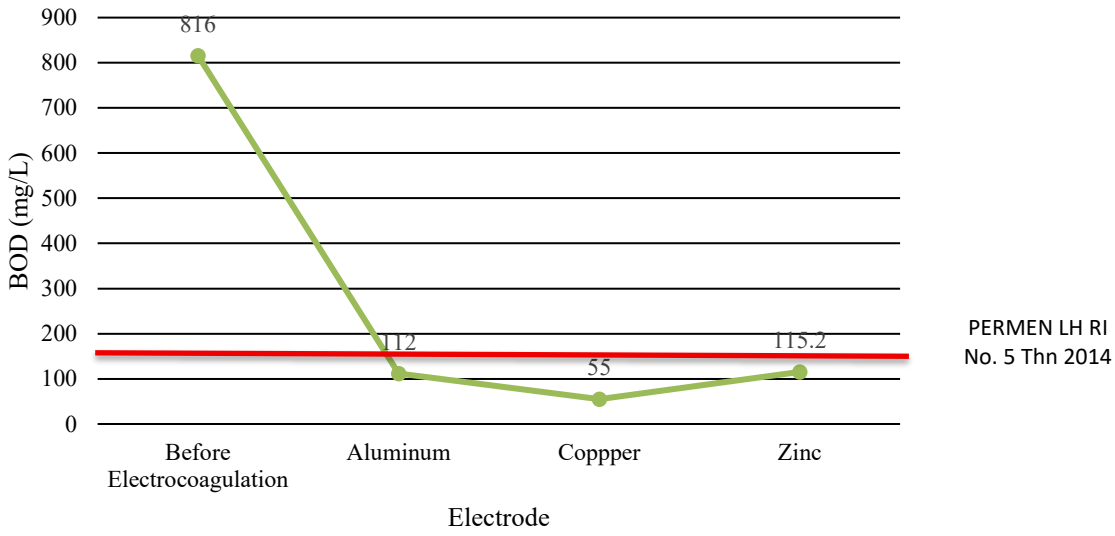

Figure 4. BOD testing before and after electrocoagulation process.

Figure 4 shows that there is a decrease in BOD levels in tofu wastewater after the electrocoagulation process and before the electrocoagulation process, the BOD value was recorded at 816 mg/L. After the electrocoagulation process using electrode variations (aluminum, copper, and zinc), there was a decrease in BOD value. With aluminum electrodes, BOD decreased to 112 mg/L or about 86.27%. The use of copper electrodes resulted in the most significant decrease to 55 mg/L, equivalent to 93.25%. Meanwhile, the zinc electrode reduced BOD to 115.2 mg/L or about 85.88%. The most substantial decrease in BOD occurred with the copper electrode, highlighting its effectiveness in significantly lowering the organic content of tofu liquid waste. In the electrocoagulation process, electrodes play a crucial role as a medium for delivering electric current into the solution, which initiates the necessary chemical reactions for pollutant removal. The decrease in BOD value reflects that electrocoagulation is very effective in removing dissolved organic compounds, because high BOD levels indicate many organic compounds that can still be decomposed by microorganisms.

To assess the effectiveness of electrocoagulation in treating tofu liquid waste, COD testing was conducted to observe reductions in pollutant levels. A substantial decrease in COD signifies the method's capability in removing organic matter. This study utilized aluminum, copper, and zinc electrodes for COD analysis, with the results depicted in Figure 5.

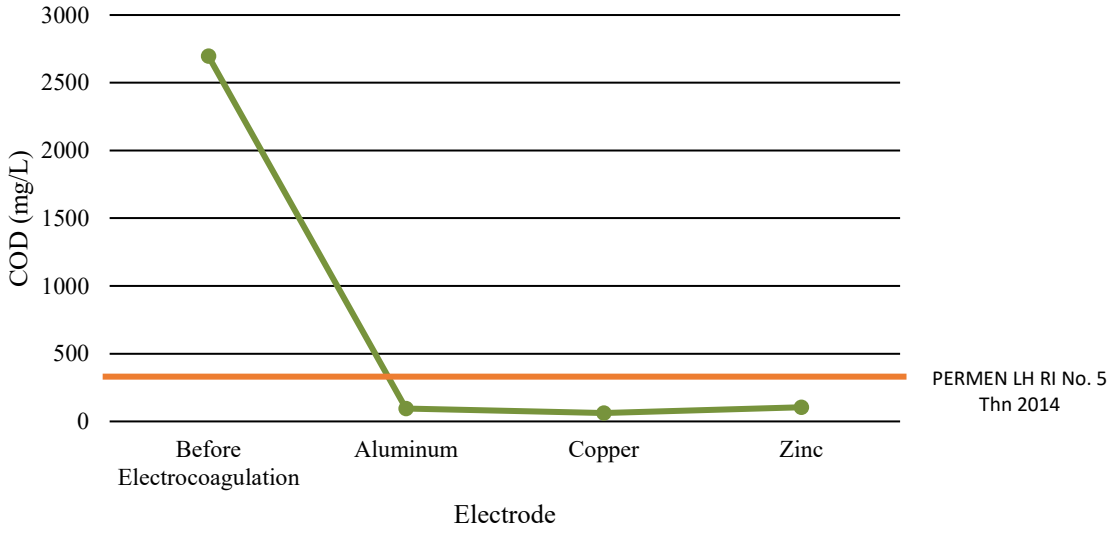

Figure 5. COD testing before and after electrocoagulation process.

Figure 5 shows that there is a decrease in COD concentration in tofu wastewater after going through the electrocoagulation process. Before treatment, the COD level was recorded at 2696 mg/L. After the electrocoagulation process using electrode variations (aluminum, copper, and zinc), there was a decrease in COD levels. Applying aluminum electrodes reduced COD levels to 95 mg/L, indicating a 96.47% removal rate. The use of copper electrodes proved even more effective, lowering the COD level to 62 mg/L and reaching the highest removal efficiency of 97.70%. Meanwhile, zinc electrodes lowered the COD to 105 mg/L, corresponding to a 96.10% reduction. The highest reduction was achieved with copper electrodes which reduced COD to 62 mg/L, or about 97.70% of the initial value. The effectiveness of this COD reduction is related to the oxidation-reduction process that takes place in the reactor, where hydrogen and oxygen gases are formed on the electrodes which play a role in reducing the COD content.

3. Conclusion

The findings reveal that among the electrode variations used in the electrocoagulation process, copper (Cu) electrodes demonstrate superior effectiveness in lowering BOD and COD levels in tofu liquid waste, making them more capable of meeting the required wastewater quality standards compared to aluminum (Al) and zinc (Zn) electrodes.

References

[1] K. Ansari and A. N. Shrikhande, "Feasibility on grey water treatment by electrocoagulation process: A review," *Int. J. Emerg. Technol.,* vol. 10, no. 1, pp. 85–92, 2019.
[2] B. A. Aris, Rudi, and Lasarido, "Pengelolaan Limbah Industri Tahu Menggunakan," *J. AGRIFOR*, vol. 20, no. 2, pp. 257–264, 2021.
[3] F. Sayow, B. V. J. Polii, W. Tilaar, and K. D. Augustine, "Analisis Kandungan Limbah Industri Tahu Dan Tempe Rahayu Di Kelurahan Uner Kecamatan Kawangkoan Kabupaten Minahasa," *Agri- Sosioekonomi*, vol. 16, no. 2, p. 245, 2020.
[4] W. P. Pangestu, H. Sadida, and D. Vitasari, "Pengaruh Kadar BOD, COD, pH dan TSS Pada Limbah Cair Industri Tahu dengan Metode Media Filter Adsorben Alam dan Elektrokoagulasi," *Media Ilm. Tek. Lingkung.*, vol. 6, no. 2, pp. 74–80, 2021.
[5] Kementrian Lingkungan Hidup, "Review Essay: The Third Way," *Peratur. Menteri Lingkung. Hidup Republik Indones. No.5 Tahun 2014 Tentang baku mutu air limbah*, vol. 52, no. 2, pp. 174–180, 2014.
[6] N. Subuharni, Masthura, and E. Jumiati, "Penurunan Kadar TSS Dan BOD Pada Pengolahan Limbah Cair Tahu Dengan Metode Elektrokoagulasi," *J. Redoks*, vol. 8, no. 2, pp. 41–47, 2023.
[7] M. Ammar, E. Yousef, M. A. Mahmoud, S. Ashraf, and J. Baltrusaitis, "A Comprehensive Review of the Developments in Electrocoagulation for the Removal of Contaminants from Wastewater," *Separations*, vol. 10, no. 6, p. 337, 2023.
[8] L. Hasyyati, E. Hartati, and D. Djaenudin, "Penyisihan Krom pada Pengolahan Air Limbah Penyamakan Kulit Menggunakan Metode Elektrokoagulasi," *J. Serambi Eng.*, vol. 5, no. 4, pp. 1313– 1320, 2020.
[9] Rakhmania et al., "Recent Applications of the Electrocoagulation Process on Agro-Based Industrial Wastewater: A Review," *Sustain.*, vol. 14, no. 4, pp. 1–19, 2022.
[10] M. Masrullita, L. Hakim, R. Nurlaila, and N. Azila, "Pengaruh Waktu Dan Kuat Arus Pada Pengolahan Air Payau Menjadi Air Bersih Dengan Proses Elektrokoagulasi," *J. Teknol. Kim. Unimal*, vol. 10, no. 1, p. 111, 2021.
[11] I. I. Fatiha and R. Irawanto, "Pengaruh limbah cair home-industri batik terhadap kemampuan Echinodorus radicans," *Gunung Djati Conf. Ser.*, vol. 6, p. 8, 2021.
[12] A. A. Amri and T. Widayatno, "Penurunan Kadar BOD, COD, TSS, dan pH pada Limbah Cair Tahu dengan Menggunakan Biofilter," *J. Inov. Tek. Kim.*, vol. 8, no. 1, p. 6, 2023.
[13] E. N. Afi'fah, S. M. Putri, U. M. Permatasari, and T. Widayatno, "Pengolahan limbah cair industri tahu dengan metode elektrokoagulasi secara kontinyu," *J. Sain dan Tek.*, vol. 5, no. 2, pp. 167–184, 2023.