



Effect of Wet Weight and Detention Time of Water Hyacinth (*Eichornia Crassipes*) on COD and BOD Parameters of Domestic Wastewater Treatment

Febrina Zulya¹, Reni Fitria Ramadhani^{1*}, and Ika Meicahayant^{1b}

¹ Mulawarman University, Samarinda East Kalimantan 75119, Indonesia
renifitriaramadhani03@gmail.com

Abstract. Domestic wastewater (greywater) has compounds that can pollute the environment, such as xenobiotics, organic compounds, and nutrients (from urine and human waste). One of the ecological alternatives to domestic wastewater treatment is phytoremediation. Phytoremediation is a method of degradation of contaminants by using plants that grow on soil and surface water. This study aims to determine the influence of variations in wet weight and residence time of water hyacinth plants (*Eichornia crassipes*) and the optimal results of phytoremediation treatment on domestic wastewater (greywater). This study uses a batch system with variations of water detention time, 2, 4, 6, and 8 days. Phytoremediation uses water hyacinth plants with three variations of wet weight: 500 grams, 1000 grams, 1500 grams. During the process, water is tested on COD and BOD parameters, and pH and wastewater temperature are measured daily. Based on the study's results, the highest decrease in COD and BOD parameters occurred at the variation of wet weight of 1000 grams on the 8th day with an efficiency of COD reduction of 82.13% and BOD of 82.31%.

Keywords: BOD, COD, Detention Time, Phytoremediation, Water Hyacinth, Wet Weight.

1 Introduction

The construction of urban facilities accompanies the increase in population as an effort by the government to meet the primary needs of the people of Samarinda in the form of housing, one of which is Flats. As a place for people to live their daily lives, flats are one of the sources of domestic wastewater in urban areas. Greywater's domestic wastewater is generated from used bath water, laundry detergents, and kitchen laundry. Greywater that enters the aquatic environment without first treatment can potentially increase COD and BOD values. The height of these two parameters can lower the dissolved oxygen level in the waters. This condition causes wastewater not to be suitable for disposal in aquatic areas [1].

One of the efforts that must be made to reduce the impact of pollution caused by greywater wastewater is to maintain the quality of wastewater discharge following applicable regulations, namely the Regulation of the Minister of Environment and Forestry of the Republic of Indonesia Number 68 of 2016 concerning Domestic

Wastewater Quality Standards. The regulation states that every business and/or activity producing domestic wastewater must treat its wastewater. Based on this, waste treatment with ecological principles is highly recommended, considering the characteristics of domestic waste, which is generally biodegradable—one of the environmental domestic wastewater treatment system alternatives is phytoremediation [2].

Phytoremediation is a method of degradation of contaminants by utilizing plants that grow on soil and surface water. This method has the advantages of being economical, sustainable, effective, and environmentally friendly as an alternative to conventional remediation technology. Plants in phytoremediation must meet specific characteristics to obtain effective results, such as good growth, production rates, and resistance to high pollution levels. They can be a good bioaccumulator [3].

One of the plants that can be used to decompose wastewater is the water hyacinth plant. Water hyacinth is an aquatic weed. Because of its rapid growth, it can cover the water's surface and cause environmental problems. On the other hand, water hyacinth is helpful because it can absorb organic, inorganic, and heavy metals, which are pollutants. Water hyacinth can be used as a medium to reduce the concentration of BOD and COD in greywater domestic wastewater, with a percentage decrease of around 50 – 68% during the stay time of 8 days [4]. According to Kalsum's research, water hyacinth can reduce COD and BOD concentrations in greywater domestic wastewater with a percentage decrease of 77% after 7 days of treatment [5].

This study aims to determine the effect of wet weight and residence time of water hyacinth plants in the phytoremediation method on domestic greywater wastewater. It is hoped that this research can produce solutions in domestic wastewater treatment to reduce the concentration of pollutant parameters so that the wastewater discharged to the recipient water body follows the domestic wastewater quality standards that have been set.

2 Research Methods

2.1 Research Tools and Materials

The tools used are batch system reactors, spectrophotometers, jerry cans, scales, thermometers, pH meters, and laboratory test equipment for COD and BOD test parameters. The materials used were water hyacinth plants (*Eichhornia crassipes*), samples of domestic wastewater greywater and laboratory test materials for UIJ COD and BOD parameters.

2.2 Sample Retrieval and Testing

Sampling was conducted at Rususnawa Mulawarman University, which is located at Jalan Mt. Kelua, Samarinda Ulu, Samarinda City. Sampling was carried out on as many as 45 liters of greywater domestic wastewater drain sample testing for COD and BOD parameters by laboratory testing. Measurements were conducted directly in the field using Horiba tools for pH and temperature parameters. This study has four treatment reactors, with the division in reactor 1 (R1) as a control containing domestic greywater

wastewater without treatment. Reactor 2 (R2) contains 500 grams of water hyacinth plants, reactor 3 (R3) contains 1000 grams of water hyacinths, and reactor 4 (R4) contains 1500 grams of water hyacinths. The volume of wastewater per reactor is 10 liters. COD and BOD parameters were measured at the time of stay to 2, 4, 6 and 8 days. Supporting parameter measurements, namely pH and wastewater temperature, are carried out every day in the afternoon.

2.3 Plant Acclimatization

Growing plants acclimatize water hyacinth in a reactor containing clean water mixed with domestic greywater wastewater for 7 days before the running process. After 7 days of acclimatization, sorting is carried out. Hyacinth plants that have been acclimatized and then weighed according to the variation of wet weight used and selected with the criteria of plant height and lots of leaves are standardized.

3 Result

3.1 Characteristics of Greywater Domestic Wastewater

Preliminary characteristic testing is needed to compare the ability of water hyacinth plants (*Eichhornia crassipes*) to reduce the organic matter content of greywater domestic wastewater before and after the phytoremediation process. The initial characteristics of domestic wastewater can be seen in Table 1.

Table 1. Results of the Initial Characteristics Test of Greywater Domestic Wastewater

No.	Parameters	Result	Quality Standards
1.	COD	188 mg/L	100 mg/L
2.	BOD	65 mg/L	30 mg/L
3.	Ph	7,55	6–9
4.	Temperature	28°C	-

3.2 Chemical Oxygen Demand (COD) Parameter Test Results

The analysis of COD parameters after processing was carried out with variations in residence time of 2, 4, 6, and 8 days through the phytoremediation process using water hyacinth plants (*Eichhornia crassipes*), can be seen in Fig. 1.

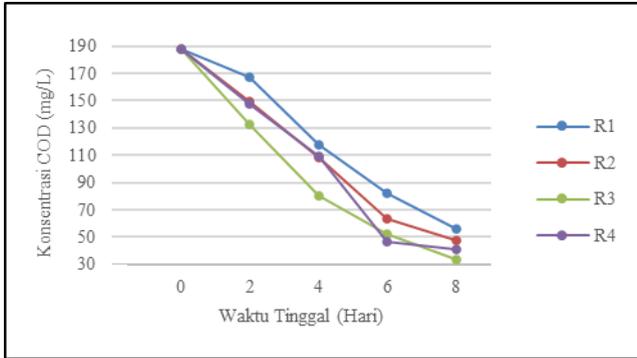


Fig. 1. Graph of COD Parameter Test Results

The initial COD concentration of domestic greywater wastewater before treatment was 188 mg/L. In reactors 2, 3, and 4 treated with water hyacinth plants, the COD concentration was reduced by 74.89%, 82.13%, and 78.14%, respectively. These results show that the best decrease occurred in the variation in wet weight of 1,000 grams of water hyacinth.

3.3 Biological Oxygen Demand (BOD) Parameter Test Results

The analysis of BOD parameters after processing was carried out with variations in residence time of 2, 4, 6, and 8 days through the phytoremediation process using water hyacinth plants (*Eichornia crassipes*), can be seen in Fig. 2.

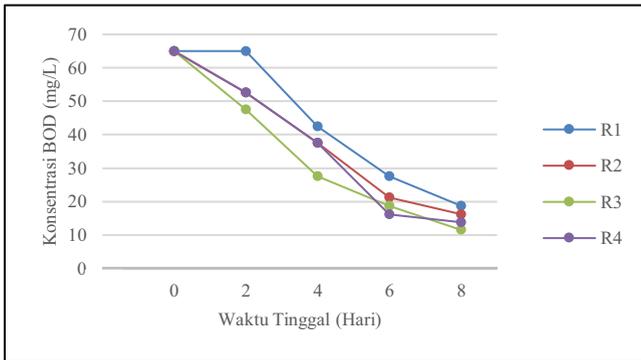


Fig. 2. Graph of BOD Parameter Test Results

Before treatment, the initial concentration of BOD of domestic greywater wastewater was 65 mg/L. During phytoremediation, the concentration of BOD decreased on the 8th day of residence with a decrease in efficiency in reactors 2, 3, and 4 of 75.08%, 82.31%, and 78.77%, respectively. These results show that the best decrease occurred in the variation in wet weight of 1,000 grams of water hyacinth.

3.4 pH Analysis

Based on the results of the final test of the pH parameter, it can be seen that the trend of pH decline in domestic greywater wastewater during 8 days of treatment with phytoremediation is presented in Fig. 3.

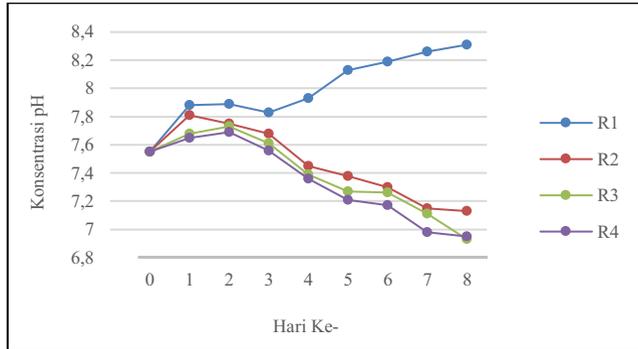


Fig. 3. Graph of pH Parameter Test Results

Reactor 1, which contains greywater domestic wastewater without plant treatment or as a control reactor, experienced an increase in pH concentration from days 1 to 8. The initial test results of the pH concentration of reactor 1 were 7.55 and increased on the 8th day to 8.31.

3.5 Temperature Analysis

Based on the results of the final test of temperature parameters, a graph of temperature measurement in greywater domestic wastewater during 8 days of treatment with phytoremediation can be in Fig. 4.

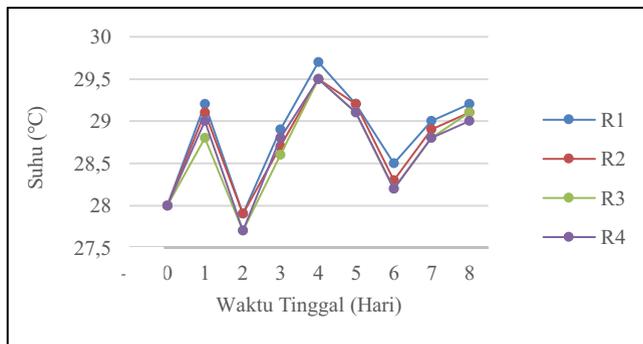


Fig. 4. Graph of Temperature Parameter Test Results

The temperature obtained from the study's results during 8 days of phytoremediation processing can be seen in Fig. 4, with an average value of 27.8°C – 29.5°C. According

to the pH, the growth of water hyacinth plants is also affected by temperature, where the optimum temperature for water hyacinth plants is 25 – 30°C. Its development will be disrupted when the wastewater temperature is below 10°C or above 40°C and will die when the water temperature is 45°C. The results of different temperature measurements every day are also affected by the weather conditions at the time of measurement; hot weather causes the temperature of wastewater to be slightly higher than low-temperature weather [4].

4 Discussion

4.1 Chemical Oxygen Demand (COD)

The decrease in COD concentration that occurs in the phytoremediation process can be influenced by two factors: the content of organic matter and the contact time of the plant. The high amount of organic matter in wastewater serves as a food source; with an abundant food supply, microorganisms multiply quickly and reduce dissolved oxygen in the water. The length of contact time also affects because the longer the contact time of water hyacinth with wastewater, the more organic matter in the form of ions can be absorbed within certain limits, which affects the level of reduction in COD concentration [4]. Organic matter is degraded by microorganisms that grow on the surface of wastewater and attach to plant roots. Microorganisms can use organic waste as a source of energy and carbon by releasing various enzymes that will break down the organic waste [6].

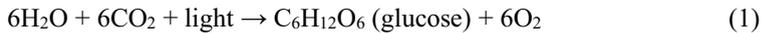
In the control reactor (R1), there was also a decrease in COD concentration due to the high organic substances in the treated domestic greywater wastewater. Organic matter in the control reactor can still be chemically degraded by oxygen diffusion from the air and microorganisms in the wastewater. Because the degradation process in the control reactor occurs naturally, the decrease in COD concentration is lower than that of the reactor heated with water hyacinth plants [7].

Based on these results, it can be seen that domestic greywater wastewater fed with water hyacinth plants has been proven to reduce COD concentration compared to those that are not treated with water hyacinth plants. This condition is also supported by research that states that *Eichhornia crassipes* has many roots so that with this root system, it can absorb organic compounds such as carbohydrates, fats, and proteins, as well as filter inorganic compounds such as soaps and detergents [5]. In addition, it can increase dissolved oxygen through the process of photosynthesis so that it can reduce COD concentration by up to 82%. The final test results of COD concentration in domestic greywater wastewater are below the quality standards following the Regulation of the Minister of Environment and Forestry of the Republic of Indonesia Number: P.68/Menlhk/Setjen/Kum.1/8/2016 concerning Domestic Wastewater Quality Standards, which is 100 mg/L.

4.2 Biological Oxygen Demand (BOD)

The decrease in BOD concentration in reactors 2, 3, and 4 can occur due to the photosynthesis process and morphology of water hyacinth plants. Plant photosynthesis produces O_2 , which microorganisms in wastewater need to break down organic matter. The higher the O_2 , the faster the microorganisms can break down organic matter so that the BOD will drop because the level of O_2 has a surplus. While plant morphology can affect the level of O_2 from photosynthesis through distance to the water surface, the closer to the water surface, the easier it will be for O_2 to diffuse into water [6].

Plants that carry out the process of photosynthesis need the help of sunlight. Plants can absorb this light because they contain green substances or chlorophyll. The sunlight will then pass through the colorless layer of the epidermis and then drive towards the mesophyll. The reactions that occur in the photosynthesis process, as in Equation 1.



Photosynthetic activity increases dissolved oxygen in waste, thus creating aerobic conditions that support aerobic bacteria to work synergistically with water hyacinths to reduce BOD values. In addition to providing oxygen for metabolism for aerobic bacteria in degrading organic matter, the plants used in phytoremediation also act as a growth medium for these bacteria. The oxygen produced by hyacinth plants is transferred to the root surface as a growth site for aerobic bacteria to support the biodegradation of organic matter and reduce BOD levels in wastewater [3].

The best decrease in BOD concentration was found in reactor 3, with a variation in the wet weight of 1000 grams of water hyacinth of 82.31%. This result shows that phytoremediation processing with a variation in damp weight of 1000 grams of water hyacinth plants has the best photosynthesis process compared to other variations in wet weight because plant density is one of the factors that plants can photosynthesize well. The decrease in BOD levels is caused by phytodegradation and organic contaminants that are absorbed through the roots and decomposed through the metabolic process in plants. The reduction of pollutants is caused by phytovolatilization, which is the absorption of pollutants by plants after phytodegradation. The pollutants are released as water vapor into the atmosphere [8].

In the control reactor, there was also a decrease in BOD concentration on the 4th to 8th day due to the sedimentation process. BOD levels will decrease if precipitation occurs, where suspended organic matter is easily decomposed. Besides that, organic levels will decrease if the growing bacteria are suspended and decomposed. The results of phytoremediation treatment show that the BOD concentration is below the quality standard following the Regulation of the Minister of Environment and Forestry of the Republic of Indonesia Number: P.68/Menlhk/Setjen/Kum.1/8/2016 concerning Domestic Wastewater Quality Standards, which is 30 mg/L [9].

4.3 pH Analysis

This alkaline pH value can be caused by the many alkaline substances found in soaps, shampoos, and detergents often used in daily activities. Dissolved oxygen contained in

the waters is then used by microorganisms for respiration and produces CO_2 . CO_2 dissolved in water will then undergo an equilibrium reaction to produce OH^- ions- causing an increase in pH value. This increase in pH is caused by a biological response, namely the decomposition process that occurs by microorganisms to organic matter in wastewater [10].

During respiration, cells aerobically produce ammonia, which can increase the pH value. The respiration reaction of microorganism cells can be seen in Equation 2.



Reactors treated with water hyacinth plants experienced a decrease in pH concentration in either reactors 2, 3 or 4. The highest reduction in pH concentration occurred in reactor three on the 8th day of stay, which was 6.93. Changes in pH values during the phytoremediation process occur due to the biochemical activity of microorganisms in wastewater and plant roots. These microorganisms will stagnate the detergent into simple compounds, namely amino acids and fatty acids (organic acids), that will produce the breakdown of proteins and fats so that the acidity will continue to decrease close to neutral pH [5]. A decrease in pH to neutral can also be influenced by the presence of exudates produced by plants that can lower the alkaline pH [7].

The concentration of free CO_2 , phytoplankton, and aquatic plants can affect the pH value of water. Aquatic plants absorb CO_2 in water during the photosynthesis process, so the pH of the water increases during the day and decreases at night. The improvement of the pH value of water in the medium can be caused by the ability of aquatic plants to absorb chemical compounds, both organic and inorganic, through chemical processes caused by environmental factors. The photosynthesis and respiration activities of aquatic plants determine changes in pH. The presence of plants in the phytoremediation test reactor affects the decrease in pH value due to the biochemical activity of microorganisms found in wastewater and in the roots of water hyacinth plants [11]. The pH value of sewage during treatment is still in the optimum range according to the quality standards in the Regulation of the Minister of Environment and Forestry of the Republic of Indonesia Number: P.68/Menlhk/Setjen/Kum.1/8/2016 concerning Domestic Wastewater Quality Standards, which is 6 – 9.

4.4 Temperature Analysis

The results show that the temperature of domestic greywater wastewater during processing is still in the optimal range for water hyacinth plants to grow well. According to the report, the normal temperature of water in Indonesian waters generally ranges from 28 – 31°C [12]. The temperature range also applies to freshwater. Based on the results of this study, the temperature ranging from 27,8 – 29,5°C is still classified as usual and does not endanger the life of aquatic biota because it is still below the lethal temperature (35 – 40°C). Temperature can affect the photosynthesis and metabolism processes of living things, with the growth temperature of aquatic plants ranging from 22 – 30°C [11].

5 Conclusions

Based on the study, the optimum results of phytoremediation treatment with water hyacinth plants (*Eichornia crassipes*) on COD and BOD parameters were found in weight variations of 1,000 grams with a residence time of 8 days, which were 82.13% and 82.31%, respectively. This result suggests that the greater the wet weight of water hyacinths does not necessarily indicate better results. Meanwhile, the residence time of plants in wastewater affects the decrease, where the longer the stay, the more significant the decrease in the concentration of COD and BOD pollutants in greywater wastewater.

Disclosure of Interests. The authors have no competing interests to declare that are relevant to the content of this article.

References

1. Mahyuddin P., Tumpu, M., Tamim, T., Edwin L.F., Rante Bungin, E., Nurdin, A.: Pengelolaan Air Limbah. (2023).
2. Ardiatma, D., Ilyas, N.I., Sara, N.U.: Efektivitas Metode Fitoremediasi dengan Tanaman Kayu Apu (*Pistia stratiotes* L.) Terhadap Penurunan Kadar BOD dalam Limbah Domestik di Jakarta. *J. Sains & Teknologi Lingkungan*. **15**, 121–133 (2023).
3. Ilmannafian, A.G., Lestari, E., Khairunisa, F.: Pengolahan Limbah Cair Pabrik Kelapa Sawit dengan Metode Filtrasi dan Fitoremediasi Menggunakan Tanaman Eceng Gondok (*Eichornia Crassipes*). *J. Teknol. Lingkung.* **21**, 244–253 (2020).
4. Putra, R. Pemanfaatan Eceng Gondok (*Eichornia crassipes*) sebagai Tanaman Phyto Treatment dalam Proses Pengolahan Limbah Cair Penyulingan Minyak Kayu Putih. *J. Ilmu Lingkungan*. **1**, 1–21 (2018).
5. Kalsum, S.U., Napoleon, A., Yudono, B.: Efektivitas Eceng Gondok (*Eichornia crassipes*), Hydrilla (*Hydrilla verticillata*), dan Rumpun Payung (*Cyperus alternifolius*) dalam Pengolahan limbah Grey Water. *J. Penelit. Sains* **17**, 20–25 (2014).
6. Gata, A.T. Tanaman Apu-Apu dalam Menurunkan Kadar Limbah Rumah Sakit. *Ruwa Jurai J. Kesehatan. Lingkungan* **12**, 23 (2021).
7. Ryanita, P.K.Y., Arsana, I.N., Juliasih, N.K.A.: Fitoremediasi dengan Tanaman Air untuk Mengolah Air Limbah Domestik. *Jurnal Widya Biologi* **11**(2) (2020).
8. Riyanto, A.: Fitoremediasi Kayu Apu, Eceng Gondok, dan Bambu Air untuk Menurunkan Kadar BOD Air Limbah Pabrik Tahu. *J. Ilmu Kesehat. Masy.* **12**, 162–170 (2023).
9. Sasiang, E., Maddusa, S.S., Oksfriani, J.S.: Efektivitas Instalasi Pengolahan Air Limbah Berdasarkan Parameter Biological Oxygen Demand, Chemical Oxygen Demand dan Derajat Keasaman di Rumah Sakit Umumgimim Pancaran Kasih Manado. *Kesmas* **8**, 608–615 (2019).
10. Putri, F., Sasmita, A., Asmura, J.: Pengaruh pH Terhadap Evesiensi Air Limbah Grey Water dengan Media Honeycomb. *Jurnal Online Mahasiswa (JOM) Bidang Teknik dan Sains* **8**(1), 56–64 (2021).
11. Yulianto, R.M., Safitri, E., Sintya, I., Savira, W., Fitrihidajati, H., Rachmardiarti, F., Lailani, I.: Kemampuan Enceng Gondok (*Eichornia crassipes*) sebagai Agen Fitoremediasi LAS (Linier Alkyl Benzene Sulphonate) Detergen. In: *Pros. SEMNAS BIO 952–960* (2021).

12. Nadhifah, I.I., Fajarwati, P., Sulistiyowati, E.: Fitoremediasi dengan Wetland System Menggunakan Eceng Gondok (*Eichhornia crassipes*), Genjer (*Limnocharis flava*), dan Semanggi (*Marsilea crenata*) untuk Mengolah Air Limbah Domestik. *Al-Kauniah J. Biol.* **12**, 38–45 (2019).

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