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Effectiveness of Apuwood Plants (Pistia Stratiotes) Using the Phytoremediation Method in Reducing Bod Levels in Ciprat Langitan Magetan Batik Waste

Rizqi Isna Febrianti[1*], Pipid Ari Wibowo[2], Avicena Sakufa Marsanti[3]
Environmental Health Specialization, Public Health Undergraduate Study Program,
Stikes Bhakti Husada Mulia Madiun, Indonesia[1*23]
Email: rizqiisnaa@gmail.com[*]

ABSTRACT
The batik industry generally consists of residue, residual dye water, residual wax and batik pelorodan water. The characteristics of batik liquid waste include high levels of Biological Oxygen Demand, Chemical Oxygen Demand, and Total Suspended Solids. Batik industry waste is considered dangerous, because its characteristics can pollute waters such as turbidity in river water. The aim of this research is to determine the effectiveness of using apu wood plants (Pistia Stratiotes) in reducing the BOD value in Ciprat Langitan Simbatan Magetan batik waste. The method used in this research is experimental, with analysis using Quasi Experimental and using a Pretest-posttest Control Group Design. The results of measuring BOD levels with phytoremediation treatment of apu wood plants on the 3rd day were 114 mg/l, on the 6th day it was 71 mg/l and on the 9th day it was 53 mg/l. The percentage of effectiveness in reducing BOD levels on day 3 was 9.78%, on day 6 it was 45.31% and on the last day it was 58.20%. There was a reduction in BOD levels with phytoremediation using apu wood plants. The effectiveness of the apu wood plant in reducing BOD levels was found with an exposure time of 9 days. Apart from that, a long-standing treatment of more than 9 days can be used to measure the effectiveness of apu wood plants in reducing the BOD levels of batik liquid waste.

Keywords: Batik waste, BOD, Phytoremediation, Apu wood

INTRODUCTION

In Indonesia, the development of textiles has increased quite rapidly, for example batik cloth. As time goes by, changes in batik clothing models also develop into various motifs. One example of the development of batik is in the Magetan area. The increasing number of batik enthusiasts makes batik centres produce more than usual, 80% of the liquid waste produced by the batik industry comes from the production process (SP Dewi & Alfiah, 2022).

The batik industry is an industry that is found in people's daily lives. The manufacturing process in the batik industry includes preparation, batiking, wax removal (pelorodan) and finishing (Wibowo et al., 2019). Chemicals used in the batik industry are used in the dyeing process. The stable nature of synthetic dyes means that these dyes take a long time to decompose in the environment, thus disturbing the balance of water

bodies. This synthetic dye contains heavy metal compounds. Heavy metals found in batik industry waste are copper (Cu), chromium (Cr), lead (Pb), manganese (Mn), and nickel (Ni). This has a negative impact on the surrounding environment and public health, if the waste is thrown anywhere. For example, if waste is thrown into the ground or river, it can pollute the land and river.

Excessive chemicals used in the dyeing process produce waste water which has the potential to damage the surrounding environment. Examples of materials that cause pollution are non-organic materials, organic materials and heavy metals whose concentrations exceed the specified quality standard values. Waste that has such characteristics can cause various kinds of damage, especially to the environment and has the potential to have a long-term impact on human health.

From the description that has been explained, liquid batik waste must be analysed first before being discharged into the river. This is done to find out whether the waste is harmful to the environment or not. Therefore, various efforts will be made to overcome the problems caused by waste water. This waste has a negative impact on the environment, for example, water pollution and disruption of the photosynthesis process, causing a reduction in oxygen which can result in the death of aquatic organisms, and can cause irritation, poisoning, genetic mutations and cancer in humans.

Disposal of large amounts of chemical waste causes pollution to the surrounding environment. The batik industry generally consists of residue, residual dye water, residual wax and batik peloria water. Apart from that, the characteristics of batik liquid waste among them high levels of Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), as well as Total Suspended Solid (TSS), temperature and acidity (PH). Batik industry waste is considered dangerous, because its characteristics can pollute waters such as turbidity in river water (Hidayatullah et al., 2023).

BOD or Biological Oxygen Demand is the dissolved oxygen needed by microorganisms to oxidize chemical compounds. The BOD value does not indicate the actual amount of organic material, only the amount needed to chemically oxidize the organic material in the water

According to the Regulation of the Minister of Environment and Forestry of the Republic of Indonesia Number 5 of 2014 and Governor Regulation No. 52 of 2014 concerning waste water quality standards for textile industry waste or batik industry on the Biochemical Oxygen Demand (BOD) parameter, namely 60 mg/L(KLHK No. P.16, 2019).

One of the famous batik centres in Magetan is Ciprat Langitan batik. The batik center is in Simbatan Village, Nguntoronadi District, Magetan Regency. There are 17 workers at the Ciprat Langitan batik center. All the workers are people with disabilities who live in Simbatan Village. The batik produced by Cipat Langitan generally has splash motifs, but there are several combination motifs such as Emil lurik batik, corner lurik, gedhek lurik, wajik lurik, Bintang lurik, hancaraka, jumputan batik, canting splash combination and many more batik motifs produced by the center. the. The tools and materials for making batik include wax/wax, dye, where the color used is the remasol type, and water glass which functions to lock the color on the batik cloth.

The management of liquid batik waste at the Splash Langitan batik center is still not implemented. Lack of knowledge and costs mean that the waste produced is

immediately thrown away without any prior processing. Based on the results of direct observations, the liquid waste resulting from the coloring is immediately disposed of through a ditch that flows into an absorption well which will then be mixed with chlorine and color clarifier, after a few days it settles in the absorption well, the waste then flows into the nearest river.

The results of a preliminary study carried out at the Splash Langitan Simbatan batik center by taking a sample of 2.5 liters of liquid batik waste showed that the BOD content in batik industrial waste was 128 mg/l. Where, the BOD content had exceeded the quality standards set by Regulation of the Minister of Environment and Forestry of the Republic of Indonesia Number 5 of 2014 states that the BOD level for the textile industry should be 60mg/l.

The importance of processing in the batik industry before it is discharged into river bodies means that further action is needed regarding waste processing, limited land and technology means that the waste is disposed of into the environment. This has a bad effect on the surrounding environment, such as a strong stench that disturbs people's comfort, besides that the biota in the river dies, and also pollutes clean water sources around the batik industry. Easy and simple waste management efforts need to be made to reduce water pollution around small and medium batik industries.

Phytoremediation is an alternative commonly used for processing liquid waste. By using reservoirs or on-site waste contaminated areas, phytoremediation can be used to address environmental problems. Phytoremediation is a method of using plants to restore soil or areas contaminated with waste. This phytoremediation method can be carried out by improving the media and the availability of microbes in the soil to increase the efficiency of the degradation process of water pollutants, so that the water becomes clean and free from pollutants.

Types of plants used to reduce pollutants in the environment have the potential to become phytoremediators in treating wastewater and waste, such as apu wood, water hyacinth, water celery, kangkong, genjer and other aquatic plants. One of the plants in the phytoremediation process is the apu wood plant, whose roots can function as a place for microbial growth and filtration, both of which can improve water quality.

Apu wood is a plant that is able to break down components in pollution. This plant is easy to find, has a fast germination rate, fast growth, high water and nutrient absorption rates, and can adapt to the climate very well. In addition, this plant can survive in calm water conditions (Daya et al., 2023). Apu wood has advantages in processing waste, such as organic and inorganic substances, even heavy metals. This plant can be used as a water phytoremediator because of its ability to collect heavy metals in its stems.

According to (Erlita et al., 2022) explained that the research that had been carried out showed that phytoremediation of water hyacinth plants was able to neutralize pollutants in batik liquid waste. This is shown in the results of the BOD and COD laboratory tests on the 7th day, the BOD content decreased by 320.8 mg/l, while the COD value was 761.4 mg/l, so it is said to have decreased because the initial BOD level was before treatment. namely 1,020 mg/l and COD of 2,000 mg/l. This research states that the longer the phytoremediation time, the better the plant's effectiveness will be.

Based on research conducted by(Masita As'ari et al., 2022)by title Phytoremediation of Tempe Wastewater Using the Apu Wood Plant (Pistia Stratiotes) showed that the Apu Wood Plant proved that it could reduce the values of the TSS, COD and BOD parameters even though the values obtained were still above the quality standards for Tempe wastewater. The most effective treatment was carried out by 15 plants, with the ability of Kayu Apu plants to reduce TSS levels for 6 days, which can be seen in the treatment of 6 plants.

Meanwhile, based on research conducted by (Daya et al., 2023) with the title Effectiveness Power Absorbing Apu Wood Plants (Pistia Stratiotes) Using the Phytoremediation Method in Reducing Bod and Cod Parameters of Liquid Batik Waste Mukti Rahayu Magetan 2023 stated that the results of the research show that the longer the days in the phytoremediation process have an effect on the process of reducing BOD and COD levels in batik industrial waste . Proven by the most effective results of reducing BOD and COD levels in this study, the 9th day variation showed the results of reducing BOD levels of 140.6 mg/l with an effectiveness level of 85.22% and the results of reducing COD levels of 227.3 mg/l with an effectiveness level of 76.5%.

From this background, research is needed on phytoremediation using aquatic plants such as apu wood to reduce river water pollution and improve the quality of liquid waste from the batik industry. This research, entitled "Effectiveness of Apu Wood Plants (Pistia Stratiotes) Using the Phytoremediation Method in Reducing BOD Levels in Ciprat Langitan Simbatan Magetan Batik Liquid Waste", aims to evaluate the effectiveness of apu wood plants in reducing BOD values in Ciprat Langitan Simbatan Magetan batik waste. The formulation of the problem is "What is the effectiveness of the Apu Wood Plant (Pistia Stratiotes) using the Phytoremediation Method in Reducing BOD Levels in Ciprat Langitan Magetan Batik Waste?", with the general aim of determining the effectiveness of the plant in reducing BOD levels, as well as specific objectives including identifying BOD levels before and after after treatment for 3, 6, and 9 days. The benefits of this research include providing input for batik center managers regarding phytoremediation methods, simple and cheap waste management alternatives, as well as teaching material for STIKES Bhakti Husada Mulia Madiun students and increasing insight and collaboration between industry and universities. The authenticity of this research compared to previous studies shows the effectiveness of phytoremediation with apu wood in reducing TSS, COD and BOD levels in various types of liquid waste, including batik waste.

RESEARCH METHODS

This research method uses an experimental approach with a Quasi Experimental design and Pretest-Posttest Control Group Design, where two groups are randomized to test initial differences before treatment.(Margareth, 2017). The research population consisted of all liquid waste produced from the Ciprat Langitan Simbatan Magetan Batik Center. Samples were taken from this liquid waste, with replication determined using the Federer formula(Epang, 2020), resulting in 6 replications with treatment for 3, 6, and 9 days, as well as one control group. The sampling technique is carried out using sterile glass bottles to take waste samples, which are then placed in a cool box to maintain sample quality.

The independent variable of the research was the BOD level in liquid batik waste, with treatment for 3, 6, and 9 days, while the dependent variable was the effectiveness of Kayu Apu plant phytoremediation in reducing BOD levels. BOD levels were measured in the laboratory using the titration method, while the treatment procedure involved the use of Kayu Apu plants which were replaced every two days. Data analysis procedures include editing, coding, and data entry with univariate analysis to identify BOD levels, as well as bivariate analysis using the One-Way Anova test to test the effectiveness of treatment (Source: Primary Data, 2024).

RESULTS AND DISCUSSION

A. Research result

1. Overview of Ciprat Langitan Simbatan Batik Center

The Sprat Langitan batik center is a center that produces batik in the form of splashed batik and hand-written batik. Apart from batik, this center also produces liquid waste from its production process. Liquid waste is liquid waste originating from households, trade, offices, industry or other public places which usually contain materials or substances that can endanger human health or life and disrupt environmental sustainability.

The Splash Langitan batik center is located in Simbatan Village, Nguntoronadi District, Magetan Regency. This batik center is managed by a community self-help group whose members number approximately 17 people with intellectual disability backgrounds.

2. Results of Physical Observations of the First Phytoremediation Treatment of Apuwood (Pistia Stratiotes) Plants

Observation Day 0

Observation Day 3

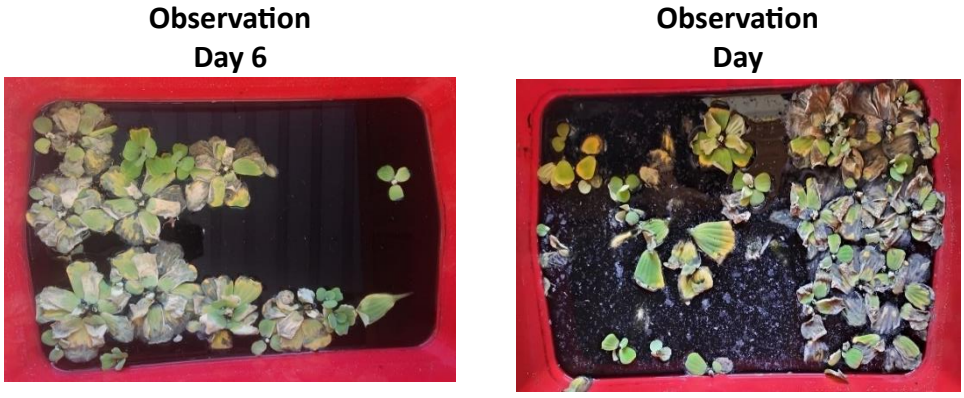

Figure 1. Treatment Observation Results
Source: Primary Data, 2024

B. Description of Observation Results

1. Day 0 Observations

   On the 0th day of observation, the condition of the apu wood plants was still fresh, there were no physical changes to the plants or even the color of the waste water. On the 0th day of observation, disturbing variables were measured, namely PH of 10, lighting of 24.20 lux, temperature of 32°C and humidity of 57%. Observations were made at 10.00 WIB.

2. Day 3 Observations

   The second observation was carried out on the 3rd day. Where the condition of the plants has started to wilt and some of the leaves have turned yellow. This is influenced by the apu wood plant which has begun to absorb the BOD and COD levels in the batik liquid waste. The pH on the 3rd day of observation was 10, lighting was 25.73 lux, temperature was 28°C and humidity was 90%.

3. Day 6 Observations

   The third observation was carried out on the 6th day. Where the physical condition of the plant is starting to rot at the leaves and base of the roots. The color of the leaf's changes to blackish yellow. On the 6th day, PH measurements were taken at 10, lighting at 45.45, temperature at 27°C and humidity at 85%.

4. Day 9 Observations

   The fourth observation was carried out on the 9th day of treatment. Where the leaves have separated from their roots, some have rotted and are black. On the 9th day, pH was measured at 7, lighting at 21.6, temperature at 27°C and humidity at 76%.

C. Table of Observation Results of Disturbing Variables in Research

Table 1. Observation Results of Nuisance Variables

Confounding Variables	Day 0	Day 3	Day 6	Day 9
PH	10	10	10	7
Lighting	24,20	25.73	45.45	21.6

Temperature	32°C	28°C	27°C	27°C
Humidity	85%	90%	85%	76%

Source: Primary Data, 2024

Based on the data above, it can be seen that the PH in waste water is 10 in the 0-6th measurement, while on the last day the PH is 7. Meanwhile, lighting is 24.20 in the first measurement, 25.76 in the second measurement, 45.45 in the third measurement and 21.6 on the fourth measurement. Lighting measurements using a lux meter. The first temperature measurement was 32 °C, the second was 28 °C, the third was 27 °C and the last was 27 °C. the last measurement is humidity, where on the first day it was measured at 85%, the second at 90%, third at 85% and last at 76%.

1. **Results of Physical Observations of the Second Phytoremediation Treatment of Apuwood (Pistia Stratiotes) Plants**

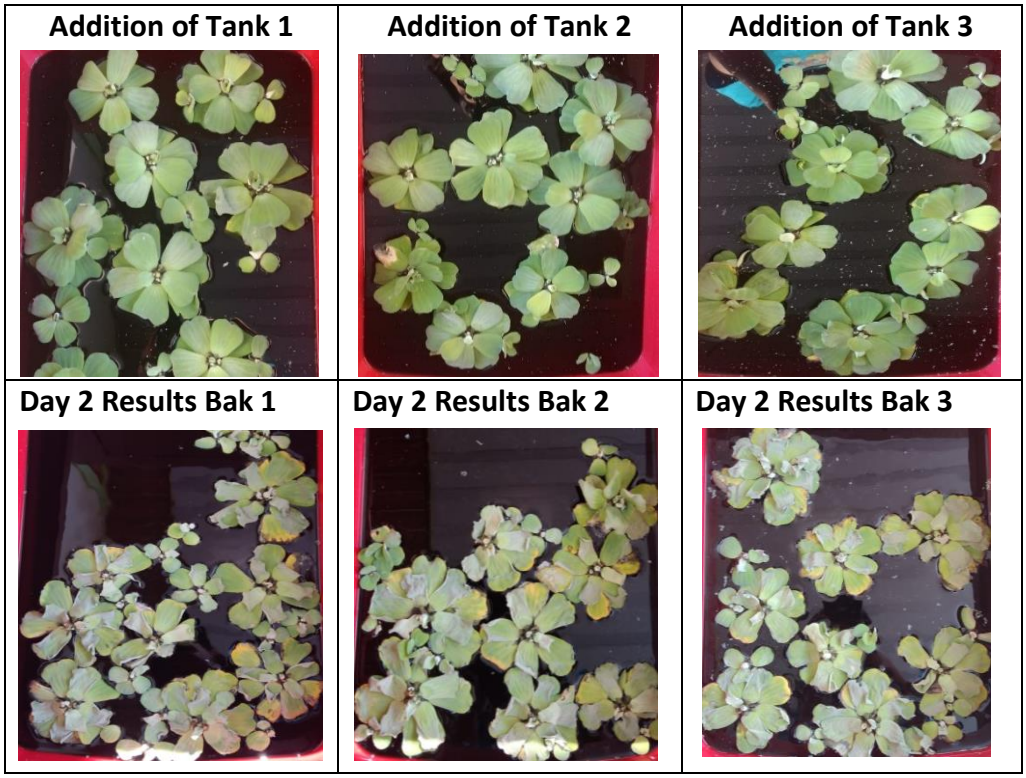

Figure 2. Second Observation Results
Source: Personal Documentation, 2024

D. Second Observation Results on Phytoremediation Treatment of Apu Wood Plants

In this second observation, the plants will be replaced after 2 days. This is intended to make plant absorption of batik waste more effective. The picture above shows the physical differences in the plants after 2 days. In the top pictures 1, 2 and 3 are the conditions of the plants that have just been replaced after 2 days. Meanwhile, in pictures below 1, 2 and 3 are the condition of the plants after 2 days of contact with liquid waste. You can see that there is a change in the color of the

plant, which was originally green, becomes wilted and turns slightly yellowish, apart from that, some of the leaf petals have separated from the roots.

E. Table of Observation Results of Disturbing Variables in the Second Treatment of Tamanan Kayu Apu Phytoremediation

Table 2. Observation Results of Nuisance Variables

Confounding Variables	Day 0	Day 3	Day 6	Day 9
PH	10	10	10	10
Lighting	25.76	34.51	30.03	40.83
Temperature	25°C	30°C	26°C	28°C
Humidity	82%	85%	90%	80%

Source: Primary Data, 2024

Based on the data above, it can be seen that the PH in waste water is 10 from observations on days 0-9. Meanwhile, lighting was 25.76 in the first measurement, 34.51 in the second measurement, 30.03 in the third measurement and 40.83 in the fourth measurement. Lighting measurements using a lux meter. The first temperature measurement was 25 °C, the second was 30 °C, the third was 26 °C and the last was 28 °C. measurementThe last one is humidity, where the first measurement is 82%, the second is 85%, the third is 90% and the last is 80%.

1. Data Analysis Results

This research was conducted in June 2024 with a total of 4 treatments, namely on day 0, day 3, day 6 and day 9. The replication used in this study was 6 times with 2 BOD measurements on the 3rd day, 6th day and 9th day. BOD laboratory measurements were carried out in the chemistry laboratory belonging to the Surabaya Ministry of Health Polytechnic, Magetan Sanitation Study Program. The research results were carried out using univariate and bivariate analysis*software*SPSS 20.

a. Data on Reducing BOD Levels in Batik Liquid Waste Using the Phytoremediation Method of Apu Wood Plants.

Table 3. Calculation Results of the Effectiveness of Reducing BOD Levels

Sample	Initial BOD	Post test (mg/l)		
		3 days	6 Days	9 Days
Repetition Sample 1	128	114	71	53
Repetition Sample 2		117	69	54
Average		115.5	70	53.5
Effectiveness		9.78%	45.31%	58.20%

Source: Primary Data, 2024

From table 3 above, it shows the results of calculating the effectiveness of BOD using the batik liquid waste phytoremediation method using apu wood

plants on the 3rd day had an effectiveness of 9.78%, on the 6th day it was 45.31% while on the 9th day it was 58%. .20%. So, it can be concluded that phytoremediation of apu wood plants with the 9th day variation is the most effective. To calculate the effectiveness value of reducing BOD and COD levels, the formula is used, namely:

$$\text{Formula} : \frac{\text{Initial BOD levels} - \text{BOD levels after treatment}}{\text{Initial BOD level}} \text{X } 100\%$$

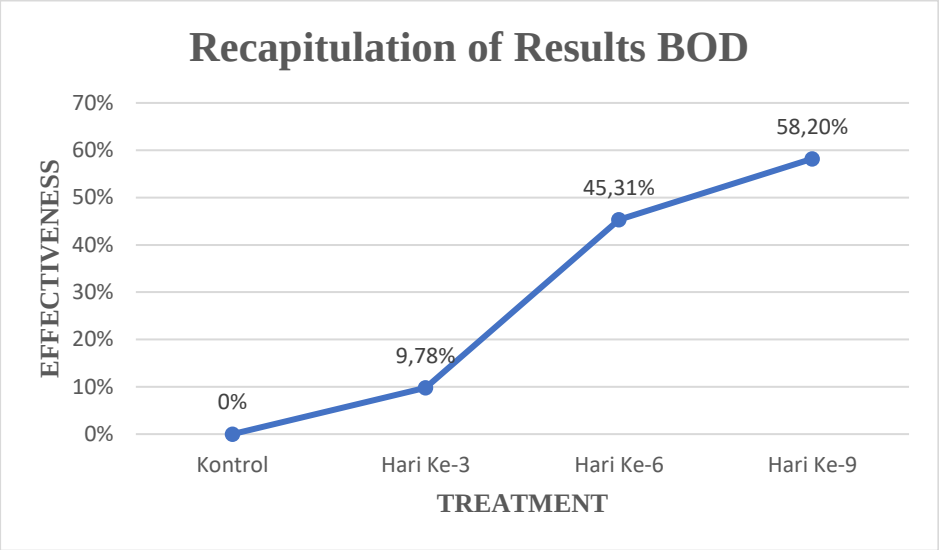

Figure 3. Graph of effectiveness of BOD reduction
Source: Primary Data, 2024

Based on the graph above, it can be concluded that there was an effective reduction in BOD levels, namely on the 3rd day of treatment it was 9.78%, on the 6th day it was 45.31%, while the highest reduction was on the 9th day of treatment, namely 58.20%.

b. Bivariate Analysis

Bivariate analysis is a continuation of univariate analysis. In this bivariate analysis using software in the form of SPSS 20 using tests*One Way ANOVA*where the conditions for the One Way Anova test include that the data is normally distributed if the p value is (≥0.05). The next requirement for using the one way anova test is that homogeneous data is shown by a homogeneity test that the data is said to be homogeneous if the significance value is >0.05.

1. Normality Test Results

Table 4. Normality Test Results

Variable	Sig.
BOD Measurement Results	0.178

Source: SPSS Data Processing, 2024

Judging from the table of normality test results above, it can be said that the two BOD variables are normally distributed because the significance value obtained by BOD is 0.178, where this value is ≥ 0.05.

2. Homogeneity Test Results

Table 5. Homogeneity Test Results

Variable	Sig.
BOD Measurement Results	0.060

Source: SPSS data processing, 2024

Based on the results of the homogeneity test, it was found that the BOD was 0.060, where this value was greater than 0.05, so the data was homogeneous or the same.

3. One Way Anova Test

Table 6. One Way Anova Test Results for BOD Variables

Variable	n	Mean ± SD	*P-Value*
BOD			
Control	2	128.00 ± 0.000	<0.001
3 days	2	115.50 ± 2.121	
6 Days	2	70.00 ± 1.414	
9 Days	2	53.50 ± 707	

Source: SPSS Data Processing, 2024

The average BOD level decreased according to the length of contact time with apu wood plants. It can be seen in table 4.8 that the initial average BOD level was 128.00, the BOD level on the 3-day treatment decreased to 115.50, on the 6-day treatment there was a decrease of 70.00 and on the 9 day it was 53.50. the results of the anova test showed that there was a significant decrease in the average BOD levels with treatment with long contact time. So, H0 is rejected, because the p value is <0.05, namely <0.001 so there is a decrease in BOD levels.

Advanced Post Hock Test

Table 7. Post Hock Test Results for the BOD variable

(I) Treatment	(J) Treatment	Mean Difference (IJ)	P Value	95% Confidence Interval	
				Lowe Bound	Upper Bound
Control	3 days	12,500	0.001	8.83	16,17
	6 Days	58,000	0,000	54.33	61.57
	9 Days	74,500	0,000	70.83	78.17
3 days	Control	-12,500	0.001	-16.17	-8.83
	6 Days	45,500	0,000	41.83	49.17

	9 ari	62,000	0,000	58.33	65.67
6 Days	Control	-58,000	0,000	-61.67	-54.33
	3 days	-45,500	0,000	-49.17	-41.83
	9 Days	16,600	0,000	12.83	20.17
9 Days	Control	-74,500	0,000	-78.17	-70.83
	3 days	-62,000	0,000	-65.67	-58.33
	6 Days	-16,500	0,000	-20.17	-12.83

Source: SPSS Data Processing, 2024

Table 7 shows that the results of post hoc analysis using the LSD (Least Significant Difference) test obtained that the control with 3 days treatment obtained a p value of 0.001, while the control with 6 days and 9 days treatment obtained a p value of 0.000, whereas in the 3 days, 6 days and 9 treatments day obtained a p value of 0.000. All probability values are smaller than the value α = 0.05, meaning that there is a significant difference between the control and the 3, 6 and 9 day treatments.

Discussion

1. **Identification of BOD Levels of Batik Waste Before Treatment**

   Before the phytoremediation treatment using apu wood plants, BOD levels were checked first, by taking a 2.5 liter water sample from the production of splashed batik, laboratory results obtained for BOD measurements were 128 mg/l.. In addition, measurements were taken related to confounding variables such as PH, Lighting, Temperature and Humidity. PH measurements on the first day showed a result of 10 or alkaline, while the lighting showed a figure of 24.20, the temperature was 32°C and the humidity was 57%. On this first day, the condition of the liquid batik wastewater before treatment was dark black and odorless.

   High amounts of BOD can damage the environment by killing species and disrupting the balance of ecosystems in waterways. Apart from that, the high level of batik waste is influenced by several factors, including the dyeing process. Chemical elements used in the synthetic dyeing process for batik can have a negative impact on the environment if they are in high concentrations.(Daya et al., 2023)

   According to the Regulation of the Minister of Environment and Forestry of the Republic of Indonesia Number 5 of 2014 and Governor Regulation No. 52 of 2014 concerning waste water quality standards for textile industry waste or batik industry on the Biochemical Oxygen Demand (BOD) parameter, namely 60 mg/L. Before being disposed of into the environment, there needs to be a process first so that the waste meets established quality standards(KLHK No. P.16, 2019).

   From the statement above, it is found that the BOD content of Cirat Langitan batik waste does not meet the environmental quality standards set by the Regulation of the Minister of Environment and Forestry of the Republic of Indonesia Number 5 of 2014 so that further treatment is needed regarding this matter. One way is to use the phytoremediation method.

2. **Identification of BOD Levels of Batik Waste After Treatment for 3 Days, 6 Days and 9 Days**

Based on the results of research that was carried out by taking 60 liters of waste water samples in a liquid waste storage tank for the Splash Langitan Simbatan batik liquid waste, which was then carried out by phytoremediation treatment using 24 apu wood (pistia stratiotes) plants. There were 4 treatment tanks with 1 tank without apu wood plants or as a control and 3 tanks with 8 apu wood plants per tank.

Measurements on the first day or before treatment resulted in a BOD level of 128 mg/l. Apart from that, disturbing variables such as PH were also measured on the first day, the results were 10 (alkaline), Lighting 24.20, temperature measurement 32°C and humidity 57%. On the 3rd day of treatment there was a decrease in BOD levels to 114 mg/l, for PH measurements the result was 10 (alkaline), lighting was 25.74, temperature was 28°C and humidity was 90%, the physical condition of the plants on the 3rd day was obtained apu wood plants that have begun to wither. The next measurement was carried out on day 6, and the BOD result was 69 mg/l, for pH 10 (alkaline), lighting 45.4, temperature 27°C and humidity 85%. On the 6th day, the apuwood plants started to turn yellow and wilt. The last measurement on day 9 showed BOD results of 53 mg/l and PH on day 9 of 7, light of 21.6, temperature of 27°C and humidity of 76%. The physical condition of the apu wood plant has turned yellow, some are black and the roots have separated from the leaves. From the measurement results, disturbing variables had no effect on apu wood plants or decreased BOD levels in batik liquid waste.

Phytoremediation is a technology that can use plants to restore soil or areas contaminated with waste. This technology can be supported by improvements in the use of growing media and the availability of microbes in the soil to increase efficiency in the degradation process of pollutant materials flowing to all parts of the plant, so that the water is clean of pollutants. Apu-apu or also known as apu wood (Pistia stratiotes) is the only genus of Pistia. Apu-apu as an aquatic plant has the potential to reduce levels of water pollutants with high organic levels. Generally, apu plants are found in calm waters such as ponds, lakes and rice fields. This plant can be used as a phytoremediator for various types of waste such as batik waste, tofu waste, and even waste containing heavy metals.(Muryani & Widiarti, 2019).

Perez Davila (2020)stated that the greater the number of apu wood plants used, the greater the concentration of BOD absorbed through the plant roots. The more plants and roots a plant has, the greater the organic material that can be absorbed in waste water.

Based on research conducted byUS Dewi et al., (2022)The more plants there are in the treatment unit and the longer the contact time of waste water with plant roots, the more efficient it will be in reducing COD levels. The decreasing value of COD levels which increases every day can be caused by the degradation process becoming more effective when the microorganisms around the roots have started to grow in large numbers. The decomposition of organic material occurs with the help of microorganisms in plant roots which will then be used by the plant for its growth. The reduction in organic compounds is directly proportional to the decrease in COD values in the waste. The decrease in COD levels can be influenced by the

growth and number of plants, because the more plants there are, the more oxygen supply will occur in the planting medium.

In accordance with the research that has been carried out, it can be concluded that the phytoremediation method is an alternative for reducing BOD levelsespecially in batik liquid waste. Apart from plants that are easy to obtain, phytoremediation is also an easy and cheap method. In this method, the length of time affects the reduction in BOD levels of batik liquid waste. The longer the contact time between the plant media and batik liquid waste, the higher the reduction that occurs.

3. Time Effectiveness of Reducing BOD Using the Phytoremediation Method

From the results of calculating the effectiveness of reducing BOD levels in Splash Langitan batik liquid waste, it was found that the decrease on day 3 was 9.78%, the decrease on day 6 was 45.31% and on day 9 was 58.20%. Based on these results, the effectiveness of reducing BOD levels was found on day 9.

The efficiency of reducing BOD levels shows that the longer the days used for the phytoremediation process in processing batik liquid waste, the greater the reduction efficiency. The use of apu wood plants as a medium in the batik wastewater phytoremediation method can reduce BOD levels because it plays a good role in supporting the rate of absorption of nutrients resulting from the decomposition of organic matter by microbes and is used in photosynthesis.

In research conducted by(US Dewi et al., 2022)The test results show that the most efficient exposure time in reducing COD levels is 9 days exposure time with a reduction percentage of 63.51%, the most efficient percent coverage area in reducing COD levels is 75% closure with a reduction percentage of 76.85%. , the most efficient interaction between the two in reducing COD levels in liquid waste is at 100% coverage area with an exposure time of 9 days. From the calculation of the percentage effectiveness of COD reduction, it is known that in the interaction of 100% coverage area with an exposure time of 9 days, COD levels decreased to 10.7 mg/L with the largest percentage reduction, namely 88.03%.

This shows that in research on phytoremediation of apu wood plants, the longer the treatment days or contact time, the greater the reduction in efficiency.

CONCLUSION

The initial BOD levels of splattered skyrocket batik waste did not meet the quality standards outlined by the Regulation of the Minister of Environment and Forestry of the Republic of Indonesia Number 5 of 2014, necessitating treatment before disposal into river bodies. Phytoremediation using apu wood plants effectively reduced BOD levels over periods of 3, 6, and 9 days, with the most significant reduction observed at the 9-day mark. It is recommended that STIKES Bhakti Husada Mulia Madiun incorporate more articles and readings on batik liquid waste processing into their curriculum to enhance environmental knowledge among students. The batik industry should adopt waste processing methods like phytoremediation to minimize environmental impact, particularly at Splash Langitan batik centers, due to its cost-effectiveness and simplicity. Further research is needed to explore phytoremediation techniques and to increase the number of apu wood plants to prevent wilting and improve treatment efficacy.

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