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Water Hyacinth Potential in The Pollution Impact Reduction of Coffee Agroindustry Wastewater

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ABSTRACT

Coffee processing wastewater originating from the coffee agroindustry has the potential to reduce environmental quality. Water hyacinth is one of the biological agents capable of reducing pollutants in wastewater through a rhizofiltration mechanism in the phytoremediation process. The pollutant-reducing ability of water hyacinth is limited, so the replacement of water hyacinth is one of the alternatives for optimizing the phytoremediation method. This research aimed to compare the replacement time of water hyacinth to the decreased parameters, namely turbidity, Biochemicals Oxygen Demand (BOD), Chemicals Oxygen Demand (COD), ammonia, and phosphate in the treatment of coffee processing wastewater using the phytoremediation method. The research stages consisted of water hyacinth acclimatization, determination of hydraulic resistance time, water hyacinth replacement time, and analysis of wastewater pollutant reduction. The density of water hyacinth used is 30 grams / L, and the incubation time is 14 days. The results showed that replacing water hyacinth improved the quality of coffee processing wastewater. The most water hyacinth replacement was on the seventh day. The percentage of turbidity parameters, Biochemicals Oxygen Demand (BOD), Chemicals Oxygen Demand (COD), ammonia (NH_3-N), and phosphate (PO_4-P) in the treatment of coffee processing wastewater with replacement of water hyacinth sequentially is 92.02%; 81.10%; 81.05%; 76.03% and 72.40%.

1. INTRODUCTION

The wet processing method of coffee cherries is one of the techniques applied to downstream agro-industrial products. This processing will produce better coffee quality (da-Mota et al., 2020; Firdissa et al., 2022). However, the application of a wet process which includes pulping, fermentation, washing, and drying, produces wastewater which causes environmental problems such as high exposure to organic matter, odour formation, increased turbidity, and decreased pH values (Ijanu et al., 2020; Campos et al., 2021). Coffee industry wastewater has the potential to reduce aesthetics and increase the value of water turbidity in water bodies if it is channelled directly without any treatment. It is due to the high Total Suspended Solid (TSS) value of 5947.56 mg/L (Novita et al., 2021). Then, in line with this, coffee processing wastewater contains high organic matter and is indicated by the values of Biochemicals Oxygen Demand (BOD) and Chemicals Oxygen Demand (COD). The BOD and COD values of the coffee processing industrial wastewater were 120.23 – 3770 mg/L and 387.05 – 4302 mg/L (Genawaw et al., 2021; Novita et al., 2021a; Wangpoom et al., 2022). Several efforts to treat coffee processing wastewater have been studied using physical, chemical, biological or combination methods (Samuel, 2021; Zagklis & Bampos, 2022). Phytoremediation is an alternative wastewater treatment

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technique that is environmentally friendly, inexpensive, and easier to apply than biological and chemical methods (Materac et al., 2015; Novita et al., 2021b; Delgado-Gonzalez et al., 2021). In line with this, coffee processing wastewater is biodegradable or has a fairly high organic matter content (Rattan et al., 2015). Phytoremediation is generally used for the treatment of wastewater containing heavy metals. Suppose the phytoremediation method handles coffee processing wastewater with high organic matter content. In that case, the organic matter is expected to be a source of nutrients to support plant growth in the phytoremediation process.

Water hyacinth is a biological agent that effectively reduces pollutants in wastewater. Water hyacinth has a hyperaccumulator ability to reduce organic and inorganic materials by supplying organic and inorganic nutrients from wastewater as a growth medium (Bais et al., 2016; Crini, 2019). Water hyacinth plants can reduce organic and inorganic matter by up to 80%. In line with this, applying phytoremediation techniques using water hyacinth can reduce BOD and COD in wastewater from agricultural activities by 75-80% (Ijanu et al., 2020; Polinska et al., 2021; Novita et al., 2022). The study of agro-industrial and domestic wastewater treatment using water hyacinth in the phytoremediation techniques with constructed wetland method reduced total suspended solid, i.e. 90% (Valipour et al., 2015; Denisi et al., 2021). Water hyacinth as a biofilter media has a limit in absorbing pollutants in wastewater. The morphological stages of water hyacinth, such as root length, growth stage, density, and wastewater characteristics, influence it.

Water hyacinth plants can absorb pollutants for 7-21 days (Rezania et al., 2016; Ali et al., 2020). Another study reported that water hyacinth has the most optimum absorption of pollutants in wastewater for 7-14 days in the phytoremediation process using both batch and semi-continuous systems (Rezania et al., 2016; Novita et al., 2022). Then, after phytoremediation for 7-14 days, water hyacinth absorption of reaches saturation point, and pollutants decrease due to a decrease in the rhizofiltration mechanism, water hyacinth operational age, and the availability of organic matter and oxygen (Rezania et al., 2016; Mi et al., 2020; Peng et al., 2020; Novita et al., 2022). In general, experiments on wastewater treatment using water hyacinth in the phytoremediation process only replaced plants once the leaves turned yellow and died. Appropriate replacement of aquatic plants positively impacts the removal of pollutants in wastewater. The purpose of this research was to compare the replacement time of water hyacinth to the decreased parameters, namely turbidity, Biochemicals Oxygen Demand (BOD), Chemicals Oxygen Demand (COD), ammonia (NH_3-N), and phosphate (PO_4-P) in the treatment of coffee processing wastewater using the phytoremediation method.

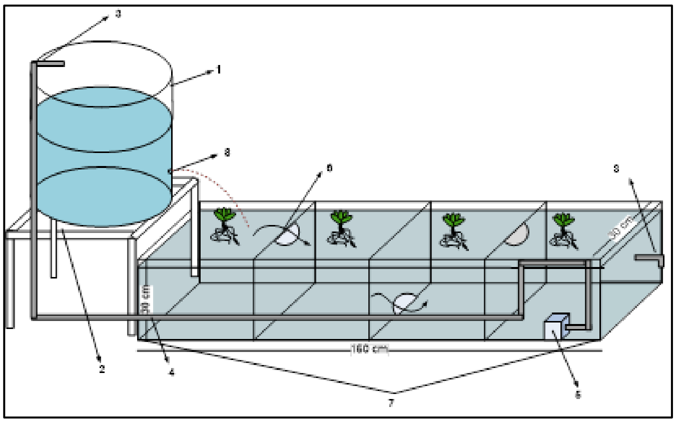
2. METHODS

This research was conducted by experimenting with the wastewater treatment of the coffee agroindustry using the phytoremediation method (batch process) with water hyacinth plants. Then quantitative descriptive is a research approach used to describe the impact of water hyacinth replacement time on the phytoremediation process with a circulation system on improving the quality of coffee agroindustry wastewater.

The research was conducted from June 2015 to April 2016. Meanwhile, the research location is in the Water Quality Laboratory-Environmental Control and Conservation Engineering, Department of Agricultural Engineering, Faculty of Agricultural Technology, University of Jember, Jember Regency. Then, wastewater samples analysis was also carried out at the Environmental Engineering Laboratory, Department of Environmental Engineering, Sepuluh Nopember Institute of Technology, Surabaya. The tools used in this study consisted of a glass aquarium that functioned as a phytoremediation reactor with dimensions of 160 cm x 30 cm x 30 cm with a working volume of 80 Liters (Figure 1), water pump KD 150, table, sample bottles, digital scales, Erlenmeyer with volume namely 125 and 250 mL, oven (Memmert Brand), ruler 50 cm, temperature incubator or refrigerator (Panasonic brand), Winkler bottles with volume 125 mL and 250 mL, volumetric flasks with volume 1000 and 2000 mL, pH meter-HI 223 (Hanna Brand), spectrophotometer-HI

83099 (Hanna Brand), turbidimeter-TN-100 (Thermo Scientific Eutech Brand), COD reactor-HI 839800 (Hanna Brand), and an acclimatization pond. The materials used in this study consisted of coffee processing wastewater from coffee agroindustry in smallholder plantations in the Jember Regency and PTPN XII Kalisat Jampit Bondowoso, water hyacinth with an average root length of 20 cm, distilled water free of ions (aquadest), reagents COD high range (HR) (Hanna Brand) with concentration value detection: 200 to 15,000 mg/L, alkaline iodide azide (laboratory grade – Merck made German), sodium thiosulfate 0.025 N (laboratory grade - Merck made German), manganese sulfate 40% (laboratory grade - Merck made German), sulfuric acid 20 N (laboratory grade - Merck made German), starch indicator 5% (laboratory grade - Merck made German), reagent N (laboratory grade - Merck made German), and sodium hydroxide 1 N (laboratory grade - Merck made German).

The working principle of the phytoremediation aquarium with circulation is that coffee processing wastewater is accommodated in a plastic tub (80 L) with a hole at the bottom. Coffee processing wastewater flows from a plastic storage tank or plastic tube to a phytoremediation reactor filled with water hyacinth. In this study, the phytoremediation method used a batch system. Coffee wastewater is circulated using the help of a water pump so that coffee processing wastewater in the aquarium remains homogeneous and nutrient absorption by water hyacinth is uniform. Circulation or discharge of coffee processing wastewater in this study, considering the Hydraulic Retention Time (HRT). According to research by Rukmawati et al. (2015), The optimal hydraulic retention time (HRT) is 8 hours 31 minutes with a flow rate of 10.61 mL/s in the phytoremediation of coffee processing wastewater using water hyacinth. The smaller the debt used, the greater or longer the HRT. The longer the HRT, the higher the decrease in turbidity, COD, BOD, TDS, N and P parameters. The HRT value is calculated using equation 1 (Valipour et al., 2015; Ghosh & Sarkar, 2021). Then, discharge was used in this research is 3.47 mL/s with an HRT of 9 hours 12 minutes. At this HRT, the wastewater flows smoothly, and there is no blockage in the flow hole.



Sketch of Phytoremediation Reactor

Explanation:

1. Plastic Tube with a Volume of 80 L
2. Table
3. Elbow (1/2 inch)
4. Hose
5. Water Pump KD 105
6. Bulk head
7. Glass Aquarium
8. Flow Hole

Figure 1. Phytoremediation Reactor

$$HRT = \frac{VAT}{IFR} \tag{1}$$

Explanation:

HRT : Hydraulic Retention Time (Hours)

VAT : The volume of the Aeration Tank (L)

IF : Influent Flow Rate (L/Hours)

Table 1. Detail of Experiment

Treatment	Experiment	
	Replacement of water hyacinth (RW)	No replacement of water hyacinth (NRW)
Water Hyacinth Replacement	water hyacinth plant, more than 50% of the leaves have withered	No
Phytoremediation Duration (Days)	14	14
Daily Parameters Examination	pH and turbidity	pH and turbidity
Initial and End Parameters Examination (on day 0 and day 14)	turbidity, BOD, COD, ammonia, and phosphate	turbidity, BOD, COD, ammonia, and phosphate
Discharge (mL/s)	3.47	3.47
HRT	9 hours 12 minutes	9 hours 12 minutes

Table 2. Data Collecting Methods and Analysis of Wastewater Quality Parameters

Parameters	Analysis Methods	References	Data Collecting
pH	Electrometric	SNI 06-6989.11-2004	During 14 days (Daily Data)
Turbidity	Spectrophotometric	QI/LKA/11	During 14 days (Daily Data) and Day 1 and 14 Data
Biochemical Oxygen Demand (BOD)	Titrimetric-Winkler Method	Standard Method: APHA 5210 B-1998	Initial and End Data (Day 1 and 14 data)
Chemical Oxygen Demand (COD)	Spectrophotometric	QI/LKA/19	
Ammonia (NH_3-N)	Spectrophotometric	SNI 06-6989.30-2005	
Phosphate (PO_4-P)	Spectrophotometric	SNI 06-6989.30-2005	

Water hyacinth is obtained from a swamp area located in Jember Regency. The selected water hyacinth has a root length average of 20 cm and is in the vegetative period (not yet flowering) (Valipour, 2015). Before water hyacinth is used as a biofilter, acclimatization is carried out first. Acclimatization aims to adjust the water hyacinth conditions to have good pollutant absorption capabilities. Acclimatization is done by placing water hyacinths in the acclimatization pond for approximately 7-14 days before being used as a biofilter. The acclimatization pond with dimensions 100 cm x 20 cm x 20 cm or 40 L contains water from rainwater reservoirs and is left exposed to direct sunlight (Elizabeth et al., 2020: Hasibuan et al., 2020; Novita et al., 2022). Before the coffee processing wastewater was placed in a glass aquarium, the initial characteristics were measured. This measurement aims to identify the initial conditions of wastewater before biological treatment is carried out to determine the efficiency of the treatment method (Jones et al., 2018; Novita et al., 2022; Simanjuntak et al., 2022).

There were 2 (two) phytoremediation experiments in this study, namely the replacement of water hyacinth (RW) and no replacement of water hyacinth (NRW) (Table 1). Each experiment contained two replications. The first experiment (RW) is to replace the water hyacinth when the leaves have withered. Water hyacinth replacement occurs if more than 50% of the leaves have withered in one water hyacinth plant. The study's characteristics of wilted water hyacinth leaves were yellowing leaves and dry leaf edges. In the second experiment (NRW), without changing the water hyacinth until the treatment ends. Both treatments used the same debit or discharge. Each process is carried out for 14 days. Another study reported that water hyacinths could grow and absorb organic matter and heavy metals in wastewater within 7-15 days (Saha et al., 2017: Safauldeen et al., 2019: Ali et al., 2020). Each aquarium has the same density of water hyacinth, which is 30 grams/L with an average root length of 20 cm. Measurement of daily parameters or measurement of parameters every day for 14 days, namely pH and turbidity. The parameters that were only measured at the beginning and end of the treatment were turbidity, BOD, COD, ammonia, and phosphate. This measurement aims to calculate the phytoremediation efficiency of coffee processing wastewater using water hyacinth. Then the measurement results will be compared with the Coffee Processing Wastewater Quality Standard, which refers to Regulation of the Minister of Environment of the Republic of Indonesia Number 5/2014 (Minister of Environment of the Republic of Indonesia, 2014).

Consideration of the performance of wastewater quality improvement using the phytoremediation method is indicated by the parameters pH, turbidity, Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), ammonia (NH_3-N), and phosphate (PO_4-P). Details of the method of measuring these parameters can be seen in Table 2.

Data analysis was carried out using a quantitative descriptive approach. This approach will describe the effect of 2 experiments on reducing pollutants in coffee processing wastewater. The decrease in pollutants is identified by the percentage value of the efficiency of reducing pollutant substances in coffee processing wastewater in the coffee agroindustry. Then the equation used to evaluate the percentage of pollutant concentration can be seen in equation 2 (Jones et al., 2018; Novita et al., 2022; Simanjuntak et al., 2022).

$$PER = \frac{Co - Ci}{Ci} \times 100\% \quad (2)$$

Explanation:

PER : Percentage of Efficiency Removal (%)

Co : Initial Pollutant Concentration (mg/L)

Ci : End Pollutant Concentration (mg/L)

A comparison of experiments based on the percentage value of the efficiency of reducing pollutant concentrations is used for further discussion in selecting treatment alternatives. The statistical test used is the General Linear Model Repeated Measures or the General Linear Model (GLM) using SPSS 16.0 software (Damanik-Ambarita et al., 2016: Araromi et al., 2018). Taking the best alternative in the water hyacinth replacement experiment in the phytoremediation process based on the overall percentage reduction value such as parameters turbidity, Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), ammonia (NH_3-N), dan phosphate (PO_4-P).

3. RESULT AND DISCUSSION

3.1. Characteristics of Coffee Processing Wastewater

Coffee processing wastewater from coffee agroindustry activities can pollute the environment if the content of water quality parameters in the waste does not meet the quality standards set by the government. These conditions can be seen in Table 3. Several parameters that do not meet wastewater quality are referred to Regulation of the Minister of Environment of the Republic of Indonesia Number 5/2014, namely, BOD, COD, and pH.

Table 3. Characteristics of Coffee Processing Wastewater

Parameters	Initial Value	End Value	Wastewater Quality Standard*	Units
Biochemical Oxygen Demand (BOD)	1,434 - 2,106	271 - 590	90	mg/L
Chemical Oxygen Demand (COD)	2,274.5 - 3,200	64.17 – 81.05	200	mg/L
Turbidity	424 – 523	42 – 64.88	-	NTU
pH	4.7-4.8	6.25 – 6.70	6-9	-
Ammonia (NH_3-N)	104.11-201.18	72.40 – 76.03	-	mg/L
Phosphate (PO_4-P)	10.71 - 67.65	5.91 – 8.59	-	mg/L

*Code: RW = Water Hyacinth Replacement

*Sources: Regulation of the Minister of Environment of the Republic of Indonesia Number 5/2014

The pH parameter indicates the chemical nature of the acidic or basic coffee processing wastewater. The pH value of the waste is 4.2 – 5.3 and is in the acid category, so it is corrosive (Novita et al., 2022). If coffee processing wastewater is directly discharged into the ground or water bodies, it can pollute the environment and threaten its biotic life. In line with this, based on chemical parameters in the form of initial values of BOD and COD of coffee processing wastewater, it indicates the presence of quite high organic matter. The organic matter is predicted to come from breaking down complex compounds such as carbohydrates, proteins, and fats found in coffee fruit flesh during fermentation into simpler compounds such as monosaccharides (Buck et al., 2021).

Comparing BOD and COD values can indicate organic matter characteristics in coffee processing wastewater. The ratio of BOD and COD values in coffee wastewater processing is > 0.1, then it indices that coffee processing wastewater contains high levels of easily decomposed organic matter (Novita et al., 2021a; Novita et al., 2022). Then the value of the ratio of BOD and COD of this wastewater is 0.65, so it is in the biodegradable category. Recommendations for wastewater treatment with a characteristic ratio of BOD and COD > 0.1, namely the biological method with the help of microorganisms and aquatic plants such as water hyacinth (Echhornia crassipes) (Saha et al., 2017; Novita et al., 2022).

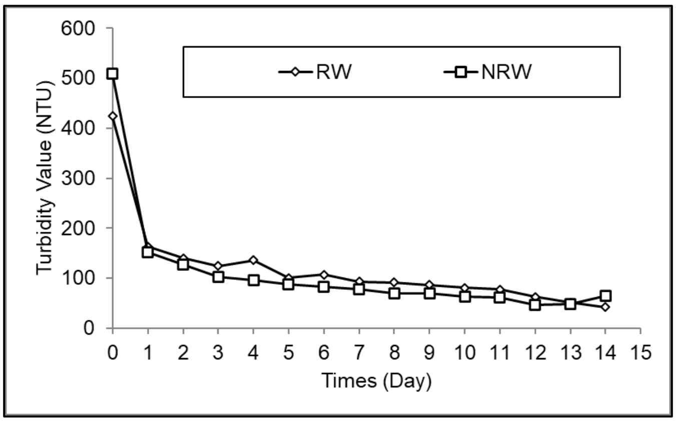
3.2. Analysis of Turbidity Parameter

Referring to Figure 1, the phytoremediation process with water hyacinth replacement reduced the turbidity value of coffee processing wastewater with a reduction efficiency value of more than 87% for all treatments. On the seventh day, the water hyacinth had withered and reached its saturation point in both the RW and NRW treatments. Furthermore, the average decrease in turbidity values was stable in the RW treatment from day 2 to day 14.

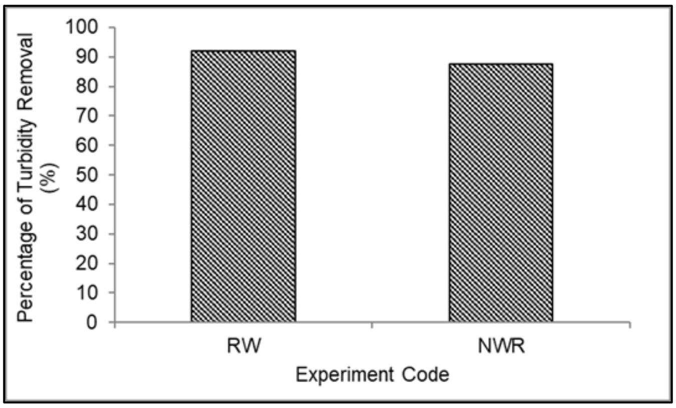
Specifically, the percentage of efficiency of decreasing turbidity parameters in RW and NRW treatments, respectively, is 92.02% and 87.60%. Suspended particles mainly cause turbidity. In this experiment, there was no precipitation phase and particle size separation through the suspended particle filtering method. Then, circulation causes the coffee processing wastewater particles not to precipitate and return to the phytoremediation reactor and are homogenized again. It happens because of the decrease in turbidity due to the decomposition of organic compounds by a plant which is also commonly referred to as phytodegradation (Polinska et al., 2021). In line with this condition, the BOD reduction efficiency values for the RW and NRW treatments were 81.10% and 64.17%, respectively. Referring to the research results by Singh and Balomajumder (2021), Water hyacinth plants have the principle of rhizofiltration to reduce turbidity through phytoextraction, phytodegradation, phytovolatilization, rhizofiltration, and phytostabilization. It is a series of processes experienced by water hyacinths to absorb contaminants and nutrients in the coffee processing wastewater to be deposited on plant parts. The replacement of water hyacinth has an impact on reducing the amount of water hyacinth that has reached its saturation point in absorbing pollutants so that water hyacinth organs such as roots improve and the living habitat of microorganisms is better so that the absorption of organic and inorganic compounds increases.

3.3. Analysis of pH Parameter

The presence of these ions in excess causes coffee processing wastewater to be acidic because it has a low pH value. This condition is supported by the results of the examination of the initial pH value in coffee processing wastewater of 4.7-4.8, which is presented in Figure 2. Coffee processing wastewater tends to be acidic, presumably due to the reshuffling of sugar in the coffee fruit flesh during fermentation. The fermentation resulted in converting glucose into acidic compounds with the help of aerobic and anaerobic microorganisms so that the pH value would tend to be low (Cruz-Salomon et al., 2018: Ijanu et al., 2020). The results of measuring the pH value for 14 days represent that the wastewater circulation system and the application of water hyacinth in each treatment greatly influence the increase in the pH value.



(a)



(b)

Figure 1. Data Trend of Turbidity Removal (a) Data Trend of Turbidity Parameter dan (b) Percentage of Turbidity Reduction

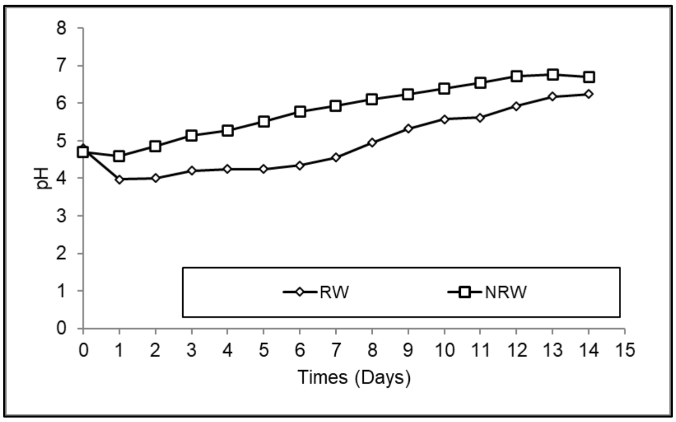


Figure 2. Fluctuation of pH Value

In the water hyacinth (RW) replacement treatment, the pH increased from the initial pH of 4.8 to day 14 of 6.3. In the treatment without replacing water hyacinth (NRW), the initial pH increased by 4.7 to 6.7. The increase in the pH of the liquid waste is due to the photosynthetic activity of water hyacinth, which requires a lot of carbon dioxide (CO_2). The process of photosynthesis is the process of taking CO_2 dissolved in water which then produces energy (glucose) and oxygen. Dissolved oxygen in water can increase the pH value. When the water hyacinth is replaced, the pH value will increase the next day because the new water hyacinth absorbs more organic matter.

3.4. Analysis of BOD and COD Parameters

Exposure to the organic matter in coffee processing wastewater can be approached by examining the BOD and COD values. Referring to Figure 3, replacing water hyacinth in the coffee agroindustry wastewater treatment contributes to an increase in the reduction of the BOD and COD values. The BOD reduction efficiency values for the RW and NRW treatments were 81.10% (271 mg/L) and 64.17% (590 mg/L), respectively. Then the COD reduction efficiency values in the RW and NRW treatments, respectively, are 81.05% (431 mg/L) and 64.18% (937 mg/L). In general, water hyacinth replacement treatment contributes to the effectiveness of remediation of exposure to the organic matter in coffee processing wastewater by more than 81.05%.

The decrease in the BOD value is the same as the decrease in the COD value caused by the periodic replacement of water hyacinth. Water hyacinth in a fresh condition is thought to increase the oxygen supply through photosynthesis and reduce organic matter as a source of nutrients. The oxygen supply during the process increases the dissolved oxygen needed by microorganisms to reduce organic matter contained in coffee processing wastewater. This phenomenon maintains the dissolved oxygen concentration to support the oxygen supply for microorganisms attached to the water hyacinth roots and in wastewater (Valipour, 2015; Novita et al., 2022). This process will oxidize compounds both easily decompose and are difficult to decompose. However, although the RW treatment has relatively high BOD and COD reduction potential, the coffee processing wastewater has not met the wastewater quality standard referred to in Regulation of the Minister of the Environment of the Republic of Indonesia

Number 5 of 2014, so secondary treatment, namely constructed wetland is needed. The comparison of the end value of BOD and COD can be seen in Table 3.

3.5. Analysis of Ammonia and Phosphate Parameters

Exposure to high macronutrients such as ammonia and phosphate can disrupt aquatic life and ecosystems. The phytoremediation method is considered appropriate for removing nutrient content. Water hyacinth plants will absorb these materials to be extracted in photosynthesis (Ali et al., 2020). This condition is in line with the study's results, which showed that the percentage reduction in ammonia and phosphate values reached more than 60%. The main cause of the decrease in ammonia content is the activity of bacteria and microorganisms such as Nitrosomonas and Nitrobacter present in water hyacinth roots which can remodel ammonia (NH_3) into nitrite (NO_2) and nitrite into nitrate (NO_3), which can be absorbed by these plants (Hasibuan et al., 2018). This process is called nitrification.

Referring to Figure 4, the percentage of ammonia parameter reduction efficiency values in the RW and NRW treatments, respectively, is 76.03% (24.96 mg/L) and 72.40% (37.63 mg/L). The water hyacinth (RW) replacement treatment was higher than the NRW treatment. It is suspected that in the RW treatment, there is still fresh water hyacinth so that the bacteria that convert ammonia into nitrite and nitrate work optimally. Under aerobic conditions or sufficient oxygen availability, Nitrosomonas and Nitrobacter bacteria can work optimally in oxidizing ammonia to nitrite and nitrate. It is different from the NRW treatment. Water hyacinth decays and even dies on the last day, resulting in anaerobic conditions (lack of oxygen). So that Nitrosomonas and Nitrobacter bacteria cannot work optimally, PE treatment can be used as an alternative in reducing the value of ammonia (NH_3). The process of nutrient conversion due to phytoremediation also occurs in phosphate.

The percentage of efficiency values for decreasing phosphate parameters in RW and NRW treatments, respectively, is 86.58% (5.91 mg/L) and 19.79% (8.59 mg/L). The availability of sufficient phosphate and the condition of water hyacinth plants that are still good affect the ability to absorb nutrients by water hyacinth. This condition will affect the efficiency of phosphate reduction. In line with this phenomenon, the RW treatment had a higher phosphate reduction efficiency value than the NRW treatment. The NRW treatment replaced water hyacinth day 14. This condition resulted in the water hyacinth reaching a saturation point to absorb pollutants and decay. The decomposition of water hyacinth can increase the phosphate value in wastewater. This condition is similar to the results of the study by Rattan et al. (2015), phytoremediation with batch method resulted in the formation of phosphate granules so that the phosphate reduction process was less than optimal. Then, the circulation method can function as a continuous stirring process and maximize the nutrient degradation process in wastewater (Valipour et al., 2015).

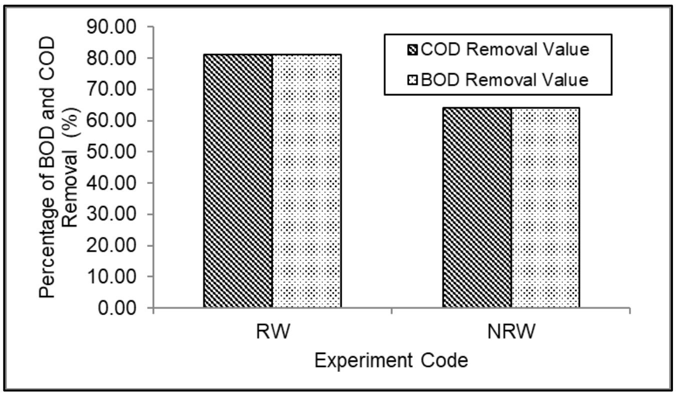


Figure 3. Percentage of BOD and COD Reduction

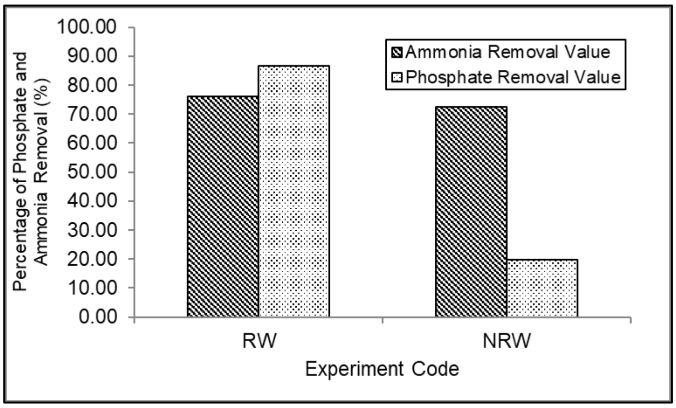


Figure 4. Percentage of Ammonia and Phosphate Reduction

Table 4. Time and Total of Water Hyacinth Replacement

Water Hyacinth Replacement Time (Day)	Number of Water Hyacinths Replacement (Stem)
1	-
2	-
3	-
4	-
5	-
6	-
7	12
8	-
9	5
10	-
11	6
12	-
13	2
14	-

3.6. Morphology Analysis Change of Water Hyachint

Water hyacinth is an aquatic plant from the kingdom Plantae and belongs to the Pontederiaceae family. Water hyacinth plants live floating in the water and have oval-shaped leaves with a tapered base and a swollen stalk. This plant can reproduce very quickly, both generatively and vegetatively. Vegetative reproduction can double in 7-14 days (Valipour et al., 2015). Water hyacinths undergo morphological changes along with the process of reducing pollutants in coffee processing wastewater. Morphological changes of water hyacinth after the phytoremediation process can be seen in Figure 5.

The roots of the water hyacinth plant change to become slimy and black. It is because the most important role in the process of absorption of organic matter is the roots. The stems of the water hyacinth plant change stem color. Initially green, it changes to yellowish and brownish. There was also a change in the leaves, which were initially green, turned yellowish and brownish withered. Leaf discoloration from green to yellow to dead water hyacinth is caused by roots absorbing contaminants in coffee processing wastewater. The cause of dead water hyacinth is due to water hyacinth carrying out the process of phytoaccumulation and phytodegradation. Phytoaccumulation is the process of plants pulling contaminants from the media so that they accumulate around plant roots. This process is known as phytoextraction, phytodegradation, phytovolatilization, rhizofiltration, and phytostabilization. Meanwhile, phytodegradation is the decomposition of contaminants by plant roots to be broken down into non-toxic organic substances.

3.7. Recommendation of Water Hyacinth Replacement Time

This research was conducted with two treatments, namely, the replacement of water hyacinth (RW) and no water hyacinth replacement (NRW). Water hyacinth is replaced when wilted water hyacinth leaves dominate one water hyacinth plant. For example, in one water hyacinth, there are eight leaves, water hyacinth replacement is carried out if at least four leaves wither. Withered leaves starting from the edges of the leaves, dry up. It is due to the inhibition of metabolism in the cells of the leaf margins, resulting in a lack of nutrients, and eventually, the cells die (Ali et al., 2020). This study replaced the withered water hyacinth with new water hyacinth.

Table 4 shows that the water hyacinth replacement treatment was carried out three times within 14-15 days (Saha et al., 2017: Safauldeen et al., 2019: Ali et al., 2020). The first water hyacinth replacement was performed on the seventh day of the RW treatment. It is because, on the seventh day, the water hyacinth has reached its saturation point. Water hyacinth plants wilt or die due to their maximum ability to absorb contaminants. After the water hyacinth reaches the saturation point in absorbing organic matter, the water hyacinth leaves wither (the edges of the leaves are dry, and the centre of the leaves is yellow). This experiment indicated that the conditions for growing water hyacinth were not fulfilled in coffee processing wastewater because it has a high enough contaminant and a low pH value, resulting in the growing conditions for water hyacinth getting worse and dying. Then, on the seventh day, not all water hyacinths reached saturation. It is influenced by the availability of nutrients or nutrients in wastewater covering organic matter, indicating BOD and COD parameters, ammonia, and phosphate. Then, the longer the number of water hyacinth plants replaced, the less on day 14. It indicates that the quality of coffee processing wastewater is getting better.

The treatment of coffee processing wastewater has various impacts on turbidity, BOD, COD, ammonia, and phosphate parameters. Therefore, the General Linear Model statistical test method is used to generalize the results of handling coffee processing wastewater using the phytoremediation method. Generalization was carried out on the RW and NRW treatments on the efficiency value of decreasing turbidity, BOD, COD, ammonia, and phosphate parameters.

(a) (b) (c)

Figure 5. Morphology Change of Water Hyacinth (a) roots, (b) leaves, and (c) stem

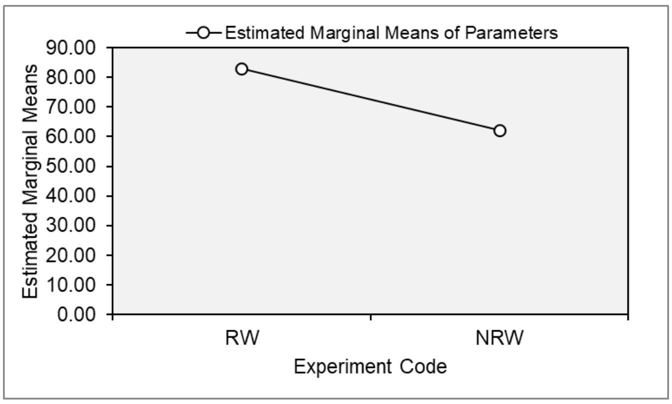


Figure 6. Graph of General Linear Model Test

Figure 6 shows that RW has an estimated marginal means value of 83.14 on the overall percentage reduction of turbidity, COD, BOD, ammonia, and phosphate. The estimated marginal means value is greater than the value in the NRW treatment. Then, the estimated marginal means for the NRW treatment is 62.20. Estimated marginal means describe the accumulated scoring for each treatment based on the parameters analyzed (Damanik-Ambarita et al., 2016: Araromi et al., 2018). Therefore, RW treatment is recommended for handling coffee agroindustry wastewater using circulation phytoremediation techniques with water hyacinth replacement. However, it is necessary to carry out further or secondary treatment so that the BOD and COD values of coffee processing wastewater still meet the quality standards in the Regulation of the Minister of the Environment of the Republic of Indonesia Number 5 of 2014.

4. CONCLUSION

The replacement of water hyacinth in phytoremediation using the circulation method in handling coffee processing wastewater has a more positive impact on improving wastewater quality than phytoremediation that does not replace water hyacinth. Then the recommendation for water hyacinth replacement is 7 days, which is the best or alternative time for processing wastewater treatment in the coffee agroindustry. It is supported by the results of statistical tests using the General Linear Model, representing that the water hyacinth replacement treatment has the highest overall value than the treatment without water hyacinth replacement. The percentage of turbidity parameters, Biochemicals Oxygen Demand (BOD), Chemicals Oxygen Demand (COD), ammonia (NH_3-N), and phosphate (PO_4-P) in the treatment of coffee processing wastewater with replacement of water hyacinth sequentially is 92.02%; 81.10%; 81.05%; 76.03% and 72.40%. Furthermore, the secondary treatment, namely filtration as a physic method or constructed wetland as combination methods for the effluent of phytoremediation applied, needs to be done considering that the BOD and COD parameters do not meet the quality standards in the Regulation of the

Minister of the Environment of the Republic of Indonesia Number 5 of 2014.

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