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Phytoremediation Study on Reducing pH, Ammonia, and Turbidity Level with Betel Ivory *(Epipremnum Aureum)* (Study Case: Contaminated Lake Water in Residential X Cibitung)

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Abstract. About 80% of the water used by humans for their activities will be thrown back in the form of wastewater from industrial and domestic. The source of waste in the lake at Residential X in Cibitung is residential activities. **Objectives:** This study aimed to determine the ability of Betel Ivory *(Epipremnum aureum)* to reduce pH, turbidity, and ammonia in lake water that was contaminated by domestic wastewater and to determine whether the phytoremediation carried out using Betel Ivory *(Epipremnum aureum)* can be applied in Residential X Cibitung. **Method and results:** The experiment was carried out using a batch system for phytoremediation, with a volume of Betel Ivory *(Epipremnum aureum)* of 13% w/w and a waste retention time of 7 days. Parameter reduction results were obtained using Betel Ivory *(Epipremnum aureum)*, where the sample experienced a higher level of decrease in pH, turbidity and ammonia parameters when compared to the control. **Conclusion:** The phytoremediation using Betel Ivory *(Epipremnum aureum)* significantly impacted the pH, turbidity, and ammonia parameters according to analysis using one-way Anova Single Factor, and the findings of the study using the T-test of equal variance met the quality standard. The potential for phytoremediation by using Betel Ivory cannot be realized because the depth of the lake reaches 8 meters and has a large number of plants.

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1 Introduction

About 80% of the water used by humans for their activities will be disposed of again in the form of polluted water in the form of industrial waste and domestic waste [1]. Surface water is the most susceptible to pollution. Anthropogenic and natural processes such as rainfall, climate change, erosion, and weathering all have an impact on surface water quality [2]. The density of people has an effect on daily activities in a given area. Increased population activity results in an increase in waste materials. Solid or liquid waste can be generated [3].

Residential X located in the Cibitung sub-district, is one of the residential areas undergoing rapid development due to its strategic location near Cikarang station and the city's shopping center. Additionally, one of the main attractions for consumers is the presence of two large lakes in Residential Area X, which support recreational activities.

Lakes are stagnant bodies of water that are more susceptible to contamination from entering waste. Waste that enters lake water will settle at the lake's bottom for an extended period [4]. Waste from community activities is the most common source of water pollution in lake waters. The source of waste from the lake in Residential Area X in Cibitung is estimated to come from residential activities.

Domestic wastewater stands as the most prevalent form of liquid waste in regions marked by heightened volume and activity. Rich in organic content, this wastewater adheres to the guidelines set by Minister of Environment and Forestry Regulation No. 68 of 2016, as it stems from human daily pursuits like utilizing bathroom water (excluding fecal matter), laundering garments, and culinary endeavors [5]. The two variations of domestic wastewater encompass suspended and dissolved constituents. Notably, such wastewater can account for as much as 70% of the overall organic load within urban liquid waste found in major cities. Within household wastewater, Total Suspended Solids (TSS) may vary between 25 to 183 mg/l, Chemical Oxygen Demand (COD) levels spanning from 100 to 700 mg/l, Biochemical Oxygen Demand (BOD) ranging from 47 to 466 mg/l, and Total Coliform figures fluctuating between 56 to 8.03x107 CFU/100 ml [6]. The substantial presence of organic matter within water fosters environmental pollution. Consequently, wastewater necessitates treatment to effectively abate pollution within aquatic surroundings and ensure its safe release into the atmosphere.

Phytoremediation is a method of waste decontamination that utilizes aquatic plants [6]. One of the aquatic plants that can be used is Betel Ivory (*Epipremnum aureum)*. Betel Ivory *(Epipremnum aureum)* is a plant that thrives in water-based growing medium. This plant is commonly used for decoration or to decorate a room; it is used by cutting Betel Ivory stems and allowing the roots to grow on their own. The Betel Ivory *(Epipremnum aureum)* plant is in high demand in countries such as Singapore and Malaysia. The presence of Betel Ivory *(Epipremnum aureum)* in nursery shops is highly sought after because, in addition to the ease of planting, there is a myth that Betel Ivory *(Epipremnum aureum)* is a plant that can provide sustenance. This plant can live well with soil and water growing media [7]. This Betel Ivory *(Epipremnum aureum)* plant can clean indoor air and absorb toxins such as formaldehyde and other pollutants. This plant can also be used as a bioremediation method to reduce lead (Pb) pollution due to motor vehicle emissions. The leaves of this plant also contain 0.8-1.8% essential oil, which contains cavikol, cavibetol, pyrocatechol, tannins, carotene, and nicotinic acid so that it can be used as a natural disinfectant [8].

According to earlier research by Ayu M.P., et al. (2022), Betel Ivory had an impact on reducing the pH parameters of domestic wastewater when it was treated using the phytoremediation method for 7 days. The research has not yet discussed which parts of the plant (roots, stems, or leaves) can aid in reducing the pH of the water. According to research studies by Novita, E., et al. (2021), kale plants are 91.2% effective at reducing turbidity parameters during phytoremediation. The Kiambang *(Salvinia molesta)* plant, which was utilized in earlier research by Hibatullah, H. F. (2019), was able to reduce BOD, COD, and ammonia when it was used with a batch system phytoremediation on domestic waste. The results showed a decrease in ammonia up to 0.000 mg/l and an efficiency of 100%, a decrease in BOD concentrations up to 11.9814 mg/l with an efficiency of 50.15%, and a decrease in COD concentrations up to 14.8289 mg/l with an efficiency of 58.00%.

The purpose of this research was to see how wastewater treatment with a phytoremediation system using Betel Ivory *(Epipremnum aureum)* media affected a decrease in pH, turbidity, and ammonia levels in lake water that was contaminated by domestic wastewater over 7 days using a batch system.

2 Methodology

2.1 Population and Sample

The population in this study is lake water that was contaminated by domestic wastewater taken from Residential X Cibitung, with a samples are 3 liters required for each observation basins.

Figure 1 illustrates the experimental sample site. Lakes and reservoirs with an average depth of less than 10 meters typically exhibit minimal temperature fluctuations, as stipulated by SNI 06-2421-1991, which mandates sampling at two locations—specifically, the lake's surface and its bottom. Nevertheless, this research solely conducted sampling at one location point.

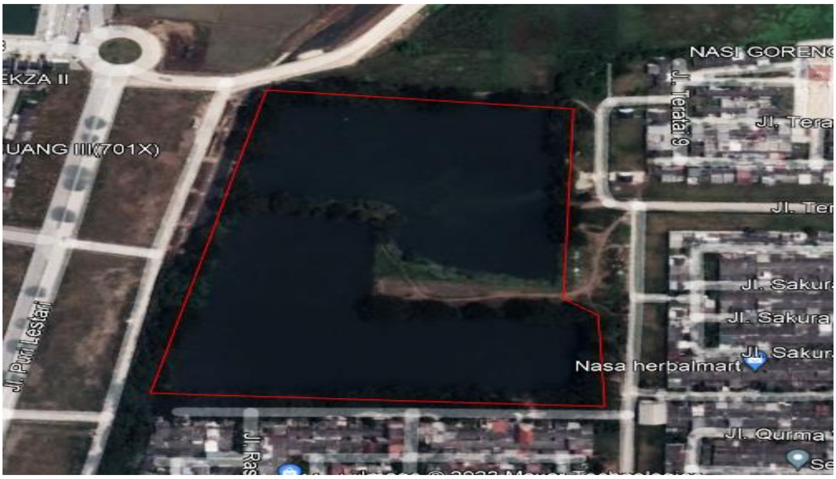

Fig. 1 Location of Sampling

2.2 Overview of Research Plan

The equipment needed for this treatment is a bucket and a rope for sampling. Furthermore, a reactor was made using a plastic basin, and in this treatment the total reactor used was 8 reactors. The reactor has dimensions of 22.5 cm in diameter and 14.5 cm in height, with a total volume of 5 liter. Then the aquatic plant that used in this experiment is Betel Ivory *(Epipremnum aureum)*. The calculations below, it results that the amount of Betel Ivory *(Epipremnum aureum)* used in this study is 13% w/w. The formula for calculating the volume of Betel Ivory is presented below.

$$Water\ Sample = 3000\ ml$$

$$Weight\ of\ Betel\ Ivory = 400\ gram$$

$$Volume\ of Basin = \pi \times r^2 \times t = 3.14\ \times 11.25^2 \times 14.5 = 5762\ cm^3$$

$$\%\ Volume\ Betel\ Ivory = \frac{400\ gram}{3000\ ml} = 13\%\ w/w$$

Next, an analytical treatment was carried out at the President's University Laboratory.

Fig. 2 Basin of Phytoremediation Experiments

With a volume of approximately 13% w/w, the aquatic plant Betel Ivory *(Epipremnum aureum)* was used in the experiment. Subsequently, Betel Ivory *(Epipremnum aureum)* was divided into two treatments, namely original lake water contaminated with domestic wastewater and lake water contaminated with domestic wastewater that had been supplemented with artificial ammonia.

There are controls and samples for each treatment, and each treatment has been replicated so that data from the first and second sets can be compared, totaling 8 basins. The use of lake water contaminated with domestic wastewater was undiluted. In this experiment, the parameters were measured every day for 7 days. Table 1 provides a description of the various types of experiments conducted.

Tabel 1 Type of Treatments

Sample	Water Volume	Betel Ivory (w/w)	NH_3 Additional Treatment	Initial NH_3 (ppm)
Control 1	3000 mL	No	No	3.65
Control 2	3000 mL	No	Yes	19.99
Sample 1	3000 mL	13%	No	3.65
Sample 2	3000 mL	13%	Yes	19.99

The dependent variable that serves as an indicator of process optimization is the parameter of pH, ammonia, and turbidity level, referring to the standard measurement method SNI 6989 11-2019 for pH, Test Kit method for ammonia, and SNI 06-6989.25-2005 for turbidity. The measurement data obtained are then used to calculate the separation efficiency value using the following Equation 1 [5].

$$Removal\ Efficiency\ (\%) = \frac{(A - B)}{A} \times 100\%$$

Information:

A = Initial Concentration (mg/l)

B = Final Concentration (mg/l)

The data will be analyzed using the t-test: Two-Sample Assuming Equal Variances, which is used to determine whether the parameters meet quality standards or not. Additionally, the One-Way ANOVA (Analysis of Variance) single factor will be used to test whether there is a significant difference between treatments in the experiment.

3 Results and Discussion

3.1 Overview of Research Plan

3.1.1 The Effect of Betel Ivory on pH, Ammonia, and Turbidity Reduction

Before processing, the initial pH, turbidity, and ammonia levels were 7.9, 36.80 NTU, 3.65 ppm (sample 1 ammonia), and 19.99 ppm (sample 2 ammonia). However, these parameters decreased after observing phytoremediation using the Betel Ivory *(Epipremnum aureum)* as seen in Table 2.

Tabel 2 The Quality of pH, Ammonia, and Turbidity Parameters in The Contaminated Lake Water Before and After Being Subjected to Phytoremediation Treatments

Treatments	pH		Ammonia (ppm)		Turbidity (NTU)	
	Initial	Final	Initial	Final	Initial	Final
Control 1	7.9	7.6	3.65	1.51	36.80	16.78
Control 2	7.9	7.62	19.99	14.23	36.80	21.15
Sample 1	7.9	7.11	3.65	0.00	36.80	2.10

Sample 2	7.9	7.10	19.99	0.00	36.80	1.13

The percentage decrease in pH is 10%. While the percentage of turbidity reduction in sample 1 was 94% and in sample 2 was 97%. The rate of reduction in ammonia levels in sample 1 and sample 2 is 100%. Efficiency graphs can be seen in Figures 3, 4, and 5.

According to the Table 2 above, Betel Ivory *(Epipremnum aureum)* reduces the pH concentration in lake water that was contaminated by domestic wastewater until 10%. Changes in pH in various media are related to nutrient uptake for plant growth. Plant growth requires a pH range of 5.0 to 6.5. If the value is too low (7.0), plant growth can be hampered or stopped [7]. Figure 3 showed the pH rempval effiiency.

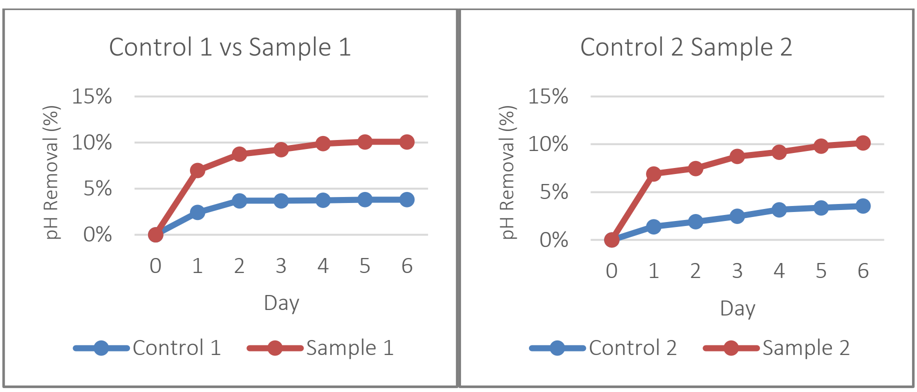

Fig. 3 pH Removal Efficiency (%) of Control vs Sample

The turbidity removal efficiency is shown in Figure 4 below, which is 54% for control 1 and 94% for sample 1. In sample 2 decreased every day when compared to sample 1, with the first day itself reaching 55%. This reduction in turbidity indicates a reduction in undissolved solids [9]. Previous research has found that the ability of plants and rhizosphere microbes in the roots to reduce turbidity is known as the rhizofiltration process in plants [10].

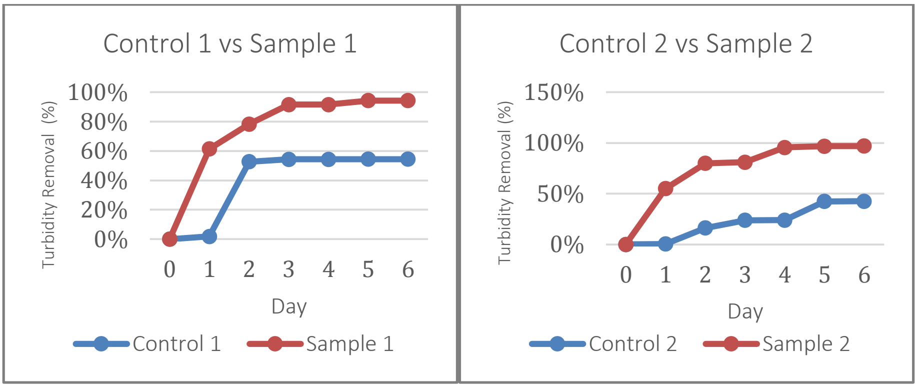

Fig. 4 Turbidity Removal Efficiency (%) of Control vs Sample

Ammonia is a non-toxic chemical compound that becomes toxic when it is not ionized. The odor of ammonia is strong and unpleasant [11]. Figure 5 below shows the efficiency of ammonia removal in sample 1 on the first day, which was 44% for control 1 and 89% for sample 1. After the phytoremediation treatment, ammonia levels were reduced to 100% on the 5th day. In sample 2 was deliberately added with ammonia and measured the initial value to be 19.99 ppm. The initial value of ammonia in sample 2 is extremely high and falls far short of the quality standard established by Government Regulation Number 22 of 2021. In contrast, to sample 1 above, there is a very large decrease in ammonia in sample 2 with a final removal efficiency value of 29% for the control and the sample is 100%. This means that phytoremediation with Betel Ivory *(Epipremnum aureum)* can still reduce ammonia levels to a fairly high value.

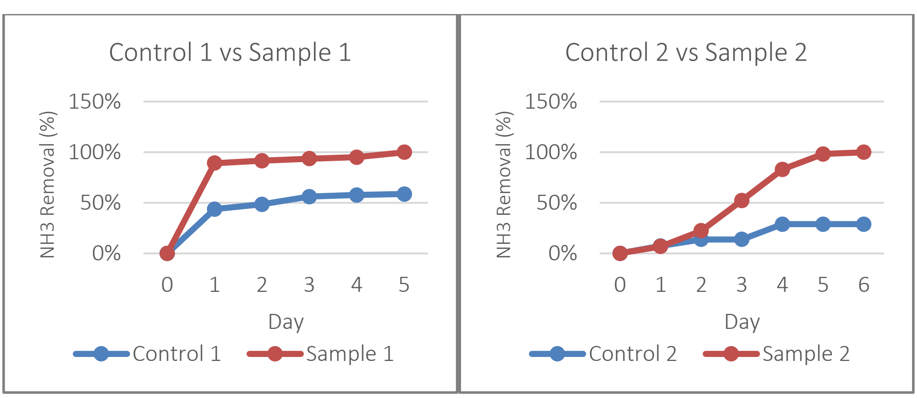

Fig. 5 Ammonia Removal Efficiency (%) of Control vs Sample

The results of reducing these parameters were obtained by using Betel Ivory *(Epipremnum aureum)*, where the samples experienced a higher degree of reduction in decreasing the concentrations of pH, turbidity, and ammonia parameters when compared to the control. The capacity of the plants and rhizosphere microorganisms to reach the roots causes a reduction [12]. Phytoextraction and rizofiltration are mechanisms of the phytoremediation process that occurs in the absorption of pH, turbidity, and ammonia. Phytoextraction is a process by which plants pull contaminants from the environment and accumulate them around plant roots. Rhizofiltration, on the other hand, is the absorption of contaminants in the roots.

If this phytoremediation is carried out under actual conditions in lake water in Residential X Cibitung, it will have negative consequences, such as dead plants settling to the bottom of the water to produce silt or deposits. The silting of the streams is caused by the deposition of plant deposits in the riverbed. If the Betel Ivory *(Epipremnum aureum)* plant covers the whole surface of the lake, it can prevent sunlight from penetrating the water, disturbing the fish generation process. On the other hand, the Betel Ivory *(Epipremnum aureum)* plant has positive impacts on the water since it can remove nitrates and algae from the water.

The results of statistical analysis using the One-Way Anova Single Factor that the Betel Ivory *(Epipremnum aureum)* was decrease in the parameters of pH, turbidity, and ammonia in all treatments. The results of statistical analysis using the T-test also that the Betel Ivory *(Epipremnum aureum)* was significant differences between each treatment in the parameters pH, turbidity, and ammonia. The difference between the treatments of intentional addition of ammonia also showed significant differences in all parameters.

3.1.2 Application in Real Case

The artificial lake has a total area is 38,830 m^2 and total depth is 8 meters which has been stated on the signs on each side of the lake. By following the method below, it is known that the volume of Betel Ivory *(Epipremnum aureum)* used in actual conditions for the lake water in Residential X Cibitung is 21780 m^2. Figure 6 shows the actual size of the artificial lake in Residential X Cibitung.

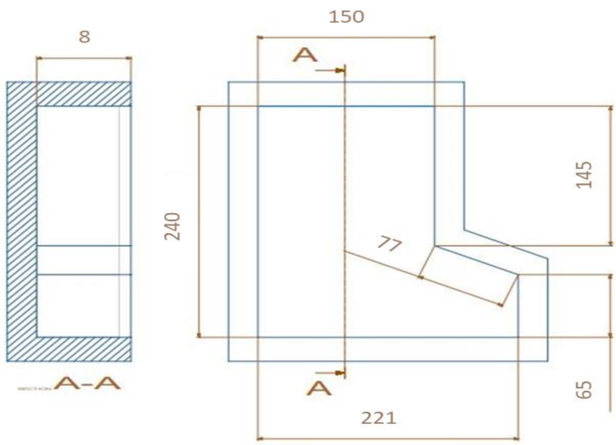

Fig. 6 The Size of The Artificial Lake Water in Residential X Cibitung

The following the calculation is used to determine the lake's surface area in Residential X Cibitung.

Given:

$$Total\ Area = 33150 + 4615 + 1065 = 38830\ m^2$$

$$Depth\ of\ Lake = 7\ meter$$

$$Volume\ of\ lake\ water = 38830\ m^3\ x\ 7\ m = 271810\ m^3$$

Then,

$$Weight\ of\ Betel\ Ivory\ x\ Volume\ of\ Water = 13\%\ {}^{w}/_{w}\ x\ 271810\ m^2$$
$$= 35335\ ton = 35{,}335{,}000\ kg$$

$$V = \frac{W}{\rho} = \frac{35{,}335{,}000\ kg}{1.5\ {}^{kg}/_{l}} = 23{,}557{,}000\ liter = 23557\ m^3$$

Assum. ρ is 0.20 meter (the depth of the plant in the water).

$$Volume\ of\ Betel\ Ivory = \frac{V}{\rho} = \frac{23557\ m^3}{0.20\ m} = 117{,}785\ m^2$$

According to Figure 14, the lake area in Residential X Cibitung is too deep to employ Betel Ivory *(Epipremnum aureum)* for phytoremediation since it reaches a depth of 7 meters. After all, the roots of the plants will not reach the bottom of the lake, and the phytoremediation process requires a large number of plants, which will disrupt the water biode. If the lake's depth is 2 meters, the phytoremediation method can be applied.

If this phytoremediation is carried out under actual conditions in the lake water in Residential X Cibitung, it will have negative consequences, such as dead plants settling to the bottom of the water to produce silt or deposits. The silting of the streams is caused by the deposition of plant deposits in the riverbed. If the Betel Ivory *(Epipremnum aureum)* plant covers the whole surface of the lake, it can prevent sunlight from penetrating the water, disturbing the fish generation process. On the other hand, the Betel Ivory *(Epipremnum aureum)* plant has positive impacts on the water since it can remove nitrates and algae from the water.

4 Conclusion

The Betel Ivory plant demonstrates significant potential in phytoremediation, with the ability to reduce levels of pH, ammonia, and turbidity in contaminated lake water. A broader application of this plant can enhance its efficiency in absorbing pollutants from the contaminated lake water, while a longer duration of the phytoremediation process may affect the plant's physical condition. However, in the case of the lake at Residential X Cibitung, the application of phytoremediation is not currently feasible due to the lake's depth, which reaches approximately 7 meters. If the lake depth were around 2 meters, the use of Betel Ivory *(Epipremnum aureum)* plants for phytoremediation could still be considered.

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