Buletin Kedokteran & Kesehatan Prima
Vol.4 No.2 (2025)
DOI: 10.34012/bkkp.v4i2.7420

ORIGINAL ARTICLE

The effects of phyto-aeration using water lilies on biochemical oxygen demand (BOD), pH, dissolved oxygen (DO), and phosphate levels in laundry wastewater

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ABSTRACT

Phytoremediation, a technique that employs plants to extract pollutants from soil and water, offers a promising solution for mitigating water contamination from liquid waste. This method is characterized by its simplicity, cost-effectiveness, high efficacy, and minimal environmental impact. It can also be aesthetically integrated into various settings to address pollution. A notable plant used in this process is the water hyacinth. Despite its rapid growth and classification as an invasive weed that can harm aquatic ecosystems, the water hyacinth possesses significant potential for environmental remediation. This research employed a quasi-experimental design with a pretest-posttest non-equivalent control group to evaluate the effectiveness of water hyacinth in reducing key pollutants. The study's primary objective was to quantify the reduction of Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), and phosphate levels in laundry liquid waste. A comparative analysis was conducted between an experimental group, where water hyacinth was utilized, and a control group. The study was conducted at the Environmental Health Engineering and Disease Control Center Class I Medan laboratory. Laundry wastewater was analyzed using spectrophotometry. The results indicated that phyto-aeration with water hyacinth was only able to achieve a 57% reduction in phosphate levels, decreasing the concentration from 1.52 mg/L to 0.65 mg/L. Further research is needed to optimize the phytoremediation process, particularly by increasing the remediation time and plant density. These modifications could potentially improve water quality by elevating dissolved oxygen (DO) levels and enhancing the biological degradation of pollutants.

Keywords: phyto-aeration, water hyacinth, laundry wastewater

Introduction

Global water pollution poses a significant threat to public health and aquatic ecosystems.[1] Globally, low-income countries treat only 8% of wastewater compared to 70% in high-income countries.[2] The United States needs to integrate advanced treatment technologies to address water scarcity and pollution. These include advanced oxidation processes, membrane bioreactors, and green technologies.[3] Untreated sewage and industrial effluents are major sources of water pollution, affecting surface and groundwater resources.[4] Implementing effective wastewater treatment is crucial for sustainable water resource management and

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economic growth.[3,4] A similar situation is observed in Indonesia, where thousands of villages and urban communities experience water contamination from household and industrial waste.[5]

Laundry businesses contribute significantly to water pollution through their wastewater discharge, which often contains high levels of detergents and phosphates.[6,7] Studies have shown that laundry wastewater can exceed regulatory standards for Biochemical Oxygen Demand (BOD) and Chemical Oxygen Demand (COD).[7] However, the impact on groundwater quality may be limited in some cases.[6] Home industries, including laundries, can also contribute to water pollution, though some studies have found BOD and COD levels within safe limits for aquatic biota.[8] Industrial activities, such as sugar factories, can significantly impact river water quality, with chemical parameters like BOD, COD, Dissolved Oxygen (DO), and pH often exceeding regulatory thresholds.[9]

Water hyacinth (*Eichhornia crassipes*) has emerged as a promising plant for phytoremediation of wastewater due to its rapid growth and impressive pollutant absorption capabilities.[10,11] Studies have shown that water hyacinth can effectively remove over 70% of various metals and metalloids, including copper, lead, and arsenic, while also improving water quality parameters such as turbidity and dissolved oxygen.[11] The plant demonstrates high efficiency in removing organic contaminants, dyes, and radionuclides from water.[12] In a 5-week experiment, water hyacinth achieved significant reductions in total suspended solids (53.03%), biochemical oxygen demand (64.41%), and heavy metals like cadmium (94.67%) and iron (30.30%).[13] Additionally, the biomass of water hyacinth can be utilized for various purposes, including animal feed, energy generation, and composting, making it a sustainable solution for wastewater management.[11,12]

In the Kecamatan Kampung Lalang area of Medan Sunggal, a high concentration of laundry businesses exists. An initial survey revealed that most of these businesses lack wastewater treatment facilities, discharging their liquid waste directly into local drainage systems or rivers. This practice poses a significant risk of water pollution, threatening both the environment and public health. Consequently, this study aims to investigate the effect of phytoaeration using water hyacinth on reducing BOD, DO, and phosphate levels in laundry wastewater in Kecamatan Kampung Lalang, Medan Sunggal, as a measure of environmental pollution mitigation.

Method

The research employed a quasi-experimental study design, specifically a pretest-posttest non-equivalent control group design. This design involved assessing the experimental group before and after an intervention. In this study, the intervention was a 3-day phytoaeration process using water hyacinths on laundry wastewater. The parameters tested were Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Dissolved Oxygen (DO), and phosphate levels in the wastewater, measured both before and after the phytoaeration. All pre- and post-intervention parameter tests were conducted at the Laboratory of the Environmental Health and Disease Control Engineering Center Class 1 in Medan. Wastewater samples were collected from a laundry facility in Kampung Lalang, Medan Sunggal, with 1 liter taken for each parameter. The data analysis was performed quantitatively using the spectrophotometry method, and the results are presented descriptively.

Results and Discussion

The parameters of biochemical oxygen demand (BOD), chemical oxygen demand (COD), dissolved oxygen (DO), and phosphate in the laundry wastewater were analyzed. The results of these tests are presented in Table 1.

Table 1. Laundry wastewater parameter tests before and after phytoremediation with water hyacinth

Parameter	Maximum Level (mg/L)	Test Result Before Phytoaeration (mg/L)	Test Result After Phytoaeration (mg/L)	Test Method
BOD	30	13,7	16,1	SNI 06-6989.72:2009
COD	100	45,2	53,2	Spectrophotometry
DO	-	4,32	4,11	SNI 06-6989.72:2009
FOSFAT	-	1,52	0,65	Spectrophotometry

Based on the study of phytoremediation of laundry wastewater using water hyacinth, an increase in BOD and COD values was observed after the treatment, while phosphate levels showed a significant decrease. Specifically, the BOD value increased from 13.7 mg/L to 16.1 mg/L, and the COD value rose from 45.2 mg/L to 53.2 mg/L. Concurrently, phosphate decreased from 1.52 mg/L to 0.65 mg/L, and the DO value slightly dropped from 4.32 mg/L to 4.11 mg/L.

Studies have demonstrated significant reductions in BOD levels, ranging from 80.65% to 96.33%.[14,15] The effectiveness of water hyacinth in reducing BOD and COD levels is influenced by factors such as plant quantity and exposure duration.[15] However, the phytoremediation process may initially lead to increased BOD and COD levels due to the release of organic material from decomposing plant biomass.[16] Water hyacinth has demonstrated adaptability to various waste concentrations, surviving in up to 30% petroleum liquid waste for approximately two months.[17] Combining water hyacinth with other plants, such as calamus, can further enhance the effectiveness of the phytoremediation process.[14]

Studies have demonstrated the effectiveness of water hyacinth in reducing various pollutants, including turbidity, COD, BOD, and nutrients.[15,18] The phytoremediation process can achieve high efficiency in pollutant removal, with BOD reduction reaching up to 96.33%.[15] However, the treatment process may lead to a decrease in dissolved oxygen (DO) levels due to increased microbial activity and organic matter decomposition.[18] Water hyacinth has also shown potential in removing heavy metals, with high bioconcentration factors observed for cadmium, copper, and iron.[13] These findings suggest that phytoremediation with water hyacinth can be a sustainable and cost-effective method for wastewater treatment, particularly in developing countries.[13,19]

Overall, the findings of this study demonstrate that phytoremediation using water hyacinth is effective in reducing phosphate levels in laundry wastewater. However, special attention to biomass management is necessary to prevent an increase in BOD and COD, which could otherwise degrade the overall quality of the treated wastewater. This is consistent with patterns found in earlier studies, which underscore the importance of biomass management strategies and the optimization of phytoremediation duration to achieve maximum treatment efficacy without adverse effects on water quality. Thus, this research contributes to and confirms the biological and environmental phenomena that occur when applying water hyacinth in wastewater phytoremediation.

Conclusion

This study demonstrates that phytoremediation using water hyacinth effectively reduces phosphate concentrations in laundry wastewater, confirming its potential as a sustainable and low-cost remediation strategy. However, an observed increase in biochemical oxygen demand (BOD) and chemical oxygen demand (COD) following treatment highlights the critical need for careful biomass management to prevent organic matter accumulation and associated water quality degradation. The slight decrease in dissolved oxygen (DO) further emphasizes the impact of microbial activity during the phytoremediation process. Consistent with previous research, these findings underscore the importance of optimizing plant density, exposure duration, and routine biomass harvesting to maximize pollutant removal efficiencies while mitigating adverse effects. Overall, water hyacinth-based phytoremediation offers promising applicability for wastewater treatment, particularly in resource-limited settings, provided that management practices are appropriately implemented.

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