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Analysis of Salvinia molesta and Water hyacinth phytoremediation processes to treat effluent using response surface methodology

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INTRODUCTION & AIM

Recent research trends show interest in overcoming the limitations of wastewater treatment systems and technologies. More researchers are investigating ecologically friendly, low-cost, and low-maintenance alternatives. More focus is being placed on environmentally friendly and sustainable treatment techniques as a result of the growing population and increasing industrialization, which have increased the pollution load on receiving water bodies from both point and non-point sources. Because of its effectiveness, affordability, and sustainability, the phytoremediation process is among the greatest ways to remediate wastewater. The system's advantages and response surface methodology (RSM) are used in this work to make predictions. This process is important for enhancing the efficiency of pollutant removal from wastewater. Phytoremediation uses plants to absorb, degrade, or stabilize contaminants, offering a sustainable and low-cost solution. RSM provides a powerful statistical tool to optimize key operational parameters, identify significant factors, and model the treatment process accurately.

METHOD

In this study, a comparative analysis was conducted to evaluate the phytoremediation potential of two aquatic plant species (Water Hyacinth and Salvinia molesta) for treating effluent from a wastewater treatment plant. The experiment was designed using controlled phytoremediation system tanks, where each species was planted separately to ensure independent observation of their performance. These tanks were filled with the same source of effluent to maintain consistency in water quality at the beginning of the treatment process. The primary operational parameters manipulated during the study were pH and hydraulic retention time (HRT), both of which are critical in influencing the effectiveness of phytoremediation. The pH of the water in the tanks was systematically adjusted to assess the tolerance and performance of each plant under varying acidity and alkalinity levels. Similarly, the HRT was varied to determine the optimal duration for maximum pollutant removal by each plant. Samples were collected at regular intervals to monitor changes in key water quality parameters. This allowed for the evaluation of the individual and comparative efficiency of Water Hyacinth and Salvinia molesta in reducing pollutants from the effluent. The findings from this methodology provide valuable insights into how different aquatic plants respond to operational variations, contributing to the development of more effective and sustainable phytoremediation systems for wastewater treatment applications.

RESULTS & DISCUSSION

The study's findings demonstrated a clear difference in the phytoremediation efficiency between Salvinia molesta and Water Hyacinth when treating wastewater effluent under varying pH conditions. Salvinia molesta showed notably higher removal efficiencies for key water quality parameters, including Chemical Oxygen Demand (COD), Total Dissolved Solids (TDS), Total Nitrogen (TN), and turbidity. At pH 5, the removal efficiencies for Salvinia molesta ranged from 51.84% to 79%, while at pH 7, the performance slightly improved, ranging from 52.12% to 83%. This suggests that neutral pH conditions may enhance the plant’s phytoremediation capabilities, possibly due to better physiological functioning or microbial synergy at this pH level. In contrast, Water Hyacinth exhibited significantly lower removal efficiencies across all parameters. At pH 5, its performance ranged from 13.56% to 48.81%, while at pH 7, it declined further, with a removal range of just 5.29% to 44.87%. These results indicate that Water Hyacinth may be less effective under the tested conditions, possibly due to lower nutrient uptake rates or less adaptability to effluent characteristics. Overall, Salvinia molesta proved to be the more effective species for pollutant removal, particularly under neutral pH conditions, highlighting its potential for use in phytoremediation-based wastewater treatment systems.

CONCLUSION

Two different plants were placed in phytoremediation system tanks to treat wastewater treatment plant's effluent. Water hyacinth and Salvinia molesta were planted in separate tanks and observed concurrently. The pH and hydraulic retention time (HRT) of the tanks were varied during operation.

The results revealed that the removal efficiency of chemical oxygen demand, total dissolved solids, total nitrogen, and turbidity were in the range of 51.84-79% for Salvinia molesta with pH 5, and 52.12-83% with pH7. Water hyacinth recorded lower performances of 13.56-48.81% and 5.29-44.87%, respectively. Accurate predictions were made from the analysis of phytoremediation treatment of wastewater utilizing the response surface approach. Integrating RSM with phytoremediation improves the effectiveness and predictability of effluent.

FUTURE WORK

Future research should explore a wider range of pH levels, long-term performance, nutrient-specific removal, and potential synergy between plant species. Studies on heavy metal removal, biomass utilization, and pilot-scale applications are also recommended for practical implementation.