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Research Article

Evaluation of biosorption ability of *Aspergillus niger*'s modified cells to remove copper from industrial wastewater

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Abstract

Introduction

Heavy metal pollution in industrial wastewater is one of the most significant challenges in preserving water resources. Copper is a prevalent metal found in the effluents of various industries, particularly in metal plating, where it is present in high concentrations. The biosorption of copper ions using renewable and accessible biosorbents has gained considerable attention as an effective treatment method. This study aims to investigate the biosorption capacity of Aspergillus niger cells for removing copper ions from industrial wastewater and to identify the parameters influencing this process. The fungal cells were pre-treated with sodium hydroxide to enhance their biosorption capacity. A specific weight of dry biomass was exposed to a copper solution, and after a defined contact time, the biomass was filtered, and the copper concentration was measured using spectrophotometry at a wavelength of 324 nm. The results indicated that the optimal biosorption efficiency was achieved using 0.1 grams of active fungal cells, reaching 81.15% at a pH of 7 with an initial copper concentration of 200 mg/L after 5 minutes at 25 degrees Celsius. When applied to real wastewater samples from the plating industry, the biosorption efficiency reached 99.94% after 60 minutes of contact time. The biosorption process followed the Langmuir isotherm model, and kinetic studies revealed that the biosorption kinetics adhered to the pseudo-second-order model, indicating the involvement of chemical adsorption processes in the biosorption of copper by Aspergillus niger cells. Additionally, the regeneration of the biosorbent and copper recovery were evaluated. This study demonstrates that Aspergillus niger can serve as an effective, cost-efficient, and environmentally friendly biosorbent for the removal and recovery of copper from metal plating wastewater.

Materials and Method

For this study, Aspergillus niger (5012) was obtained from the Persian Type Culture Collection (PTCC) in a freeze-dried form. The potato dextrose agar medium was prepared using 300 grams of potatoes, 20 grams of glucose, and 15 grams of agar in 1000 milliliters of deionized water, adjusted to a pH of 7. The medium was sterilized using an autoclave at 121 degrees Celsius for 15 minutes. For experimental purposes, the fungal strain

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was cultivated in a liquid phase at 25 degrees Celsius with shaking. The fungal spores were transferred to Erlenmeyer flasks containing the growth medium and incubated for 96 hours. The biomass was harvested during the logarithmic growth phase, washed with phosphate buffer, and dried at 60 degrees Celsius for 16 hours. The biomass was pre-treated with 0.5 M sodium hydroxide at 100 degrees Celsius for 15 minutes to enhance biosorption capacity. The biosorption experiments involved placing a specific weight of dried biomass in contact with a prepared copper sulfate solution at pH 7 for various contact times. The remaining copper concentration was measured using flame atomic absorption spectrometry (FAAS).

Results and Discussion

The results indicated that the biosorption capacity of A. niger increased with higher initial copper concentrations. The optimal biosorption efficiency was achieved at an initial concentration of 200 mg/L. The biosorption kinetics followed the pseudo-second-order model, suggesting a chemical adsorption mechanism. The maximum biosorption capacity was determined using the Langmuir isotherm model, which provided a better fit with a correlation coefficient of 0.967. The study also demonstrated that the biosorbent could effectively remove copper from real wastewater samples, achieving a removal efficiency of 99.94% after 60 minutes of contact time. Additionally, the regeneration of the biosorbent was successful, with approximately 48% of the adsorbed copper being recovered after washing with 0.1 M hydrochloric acid.

Conclusion

This study highlights the potential of using pre-treated Aspergillus niger cells as an effective biosorbent for the removal of copper (II) ions from industrial wastewater. The rapid biosorption kinetics and high capacity of this biosorbent make it a viable option for large-scale industrial applications. The biosorption process is chemically controlled, following the pseudo-second-order kinetics and the Langmuir isotherm model. The ability to recover copper and regenerate the biosorbent further supports the feasibility of this method in metal plating industries. This research provides a simple and environmentally friendly approach to treating heavy metal pollution in wastewater systems.

Conflict of Interest

The author declares no conflict of interest regarding the authorship or publication of this article.

Data availability statement

The data and results used in this research will be available through correspondence with the author.