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Effect of Eggshell Powder Concentrations in Biosorption of Methyl Red Dye

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Structured Abstract

Background: Industrial dyes, especially methyl red, are highly resistant to natural degradation leading to the accumulation of toxic compounds in aquatic ecosystems, raising environmental concerns. Traditional treatment often produces secondary pollutants and requires high operating costs, necessitates sustainable alternatives. Therefore, this study explores the potential of eggshell powder as an environmentally friendly biosorbent in methyl red removal from wastewater. Eggshells, waste from the food sector, are rich in calcium carbonate and have porous structure suitable for adsorption activities, in line with the principles of green chemistry. By analyzing different concentrations of eggshell powder, it aims to optimize sustainable methods to reduce azo dye pollution in wastewater and protect natural biodiversity.

Methods: Biosorbents were prepared from waste eggshells, which were cleaned, dried at 65°C and grounded to obtain fine particles. A portion of the eggshell powder underwent acid treatment using 0.1 M Hydrochloric acid while batch adsorption studies were conducted by varying the adsorbent concentration (0.25g/L, 1.0g/L and 2.0 g/L) in methyl red solution for a standardized time of 120 minutes. The residual dye concentration was measured using a UV-Vis Spectrophotometer at 530 nm and Two-way ANOVA was used to evaluate the significance of biosorbent concentration on the overall dye removal efficiency and adsorption rate.

Results: Eggshells treated with acid treatment showed significant methyl red decolorization compared to untreated eggshells. The treated biosorbent achieved a maximum removal concentration of 13.43% at a concentration of 2.0 g/L, doubling the 6.41% observed in untreated eggshells. Furthermore, adsorption kinetics revealed the treated eggshells accelerated the process with the rate of treated eggshells (0.0068 g/L/h) nearly twofold the untreated eggshells (0.0036 g/L/h). Both data sets exhibit a good fit to the pseudo-first-order model based on high correlation (R^2 = 0.99). Therefore, the analytical results successfully confirmed the methyl red removal was significantly dependent on the biosorbent concentration and adsorption rate.

Conclusion: In conclusion, these findings demonstrated the high potential of using acid-treated eggshells at high concentrations as sustainable biosorbents in removing methyl red dye, offering a low-cost alternative to conventional chemical treatments.

Keywords: Methyl Red, Acid-treated Eggshell, Textile Industry

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