

Wastewater Treatment Using Biochar Derived From Sugarcane Bagasse

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Abstract- The increasing demand for clean water and the rising pollution levels in aquatic systems have intensified the need for effective wastewater treatment methods. This research focuses on the application of sugarcane bagasse-derived biochar as a cost-effective and eco-friendly adsorbent. Biochar was synthesized at 400°C, 500°C, and 600°C via pyrolysis and characterized using advanced techniques such as BET for surface area, SEM for surface morphology, FTIR for functional group analysis, and TGA for thermal stability. Batch experiments revealed that biochar produced at 600°C demonstrated optimal removal efficiency for ammonia and methylene blue from synthetic wastewater. Adsorption kinetics followed the pseudo-second-order model, and isotherm studies confirmed both monolayer and heterogeneous adsorption mechanisms. The findings support the potential of sugarcane bagasse biochar as an effective material for water remediation applications.

Keywords- Absorption, Biochar, Isotherm Models, Sugarcane Bagasse, Wastewater Treatment

I. INTRODUCTION

Water pollution caused by rapid industrialization and agricultural expansion has become a global concern. Effluents containing ammonia, heavy metals, dyes, and organic pollutants pose serious risks to aquatic life and human health. Conventional treatment systems often fall short in eliminating these persistent contaminants. Biochar, a carbonaceous material produced through pyrolysis of biomass in low-oxygen environments, offers a promising solution due to its porous structure, surface functional groups, and high adsorption capacity.

II. TREATMENT METHODS

Physical Treatment Methods:

- Limited Removal of Dissolved Pollutants
- Inadequate for Complex Pollutants
- Secondary Pollution

Chemical Treatment Methods:

- Chemical Use
- Formation of Toxic By-products

Biological Treatment Methods:

- Ineffectiveness Against Non-Biodegradable Pollutants
- Sensitivity to Operational Conditions
- Sludge Production

Combined Treatment Systems:

- Complexity and Cost
- Management of By-products
- Energy Consumption

III. MATERIALS AND METHODS

Sugarcane bagasse, a byproduct of the sugar industry, was collected, dried, and pyrolyzed at 400°C, 500°C, and 600°C. The resulting biochars were analyzed using: - BET to determine surface area and porosity -SEM for microscopic morphology -FTIR for functional group identification -TGA to assess thermal degradation.

Batch adsorption studies were conducted with synthetic wastewater containing 50 mg/L ammonia and 100 mg/L methylene blue. Dosage and contact time were varied to optimize removal. Kinetics and isotherms were analyzed using pseudo-first-order, pseudo-second-order, Langmuir, and Freundlich models.

IV. RESULTS AND DISCUSSION

Biochar produced at 600°C had the highest BET surface area (405.7 m²/g), which facilitated effective removal of contaminants. At a 5 g dosage, the removal efficiency reached 88.4% for ammonia and 98.5% for methylene blue. FTIR revealed active sites such as –OH and –COOH, supporting enhanced adsorption. TGA confirmed the thermal stability of the material. The pseudo-second-order model fit

best, indicating chemisorption. Isotherm modeling suggested a combination of monolayer (Langmuir) and multilayer (Freundlich) adsorption behaviors, highlighting the complex interaction between pollutants and the heterogeneous biochar surface.

V. CONCLUSION

This study demonstrates the potential of sugarcane bagasse-derived biochar as an effective and low-cost adsorbent for wastewater treatment. Its high surface area, pore structure, and surface chemistry enable it to remove a variety of contaminants efficiently. The pyrolysis temperature significantly influences adsorption performance, with 600°C yielding the most favorable results. Future research should explore its regeneration, long-term stability, and use in continuous flow systems to assess its feasibility for industrial applications.

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