Production of Activated Biochar from Palm Kernel Shell for Methylene Blue Removal

Journal of Renewable Materials • Article • 2026 • DOI: 10.32604/jrm.2025.02025-0105

Sulaiman, Sarina ; Faris, Muhammad

Department of Chemical Engineering and Sustainability, Kulliyyah of Engineering, International Islamic University Malaysia (IIUM), Jalan Gombak, Kuala Lumpur, 53100, Malaysia

Abstract

In this study, Palm kernel shell (PKS) is utilized as a raw material to produce activated biochar as adsorbent for dye removal from wastewater, specifically methylene blue (MB) dye, by utilizing a simplified and cost-effective approach. Production of activated biochar was carried out using both a furnace and a domestic microwave oven without an inert atmosphere. Three samples of palm kernel shell (PKS) based activated biochar labeled as samples A, B and C were carbonized inside the furnace at 800°C for 1 h and then activated using the microwave-heating technique with varying heating times (0, 5, 10, and 15 min). The heating was conducted in the absence of an inert gas. Fourier Transform Infrared Spectroscopy (FTIR) highlighted a significant Si-O stretching vibration between 1040.5 to 692.7 cm^{-1}, indicating the presence of key components (Silica and Alumina) in all PKS-based activated biochar samples. For wastewater treatment, activated biochar samples were tested against

a 20 mg/L Methylene Blue (MB) solution, and the MB percentage removal was calculated for each run using a standard curve. Central Composite Design (CCD) experiments were conducted for optimization, with activated biochar Sample C exhibiting the highest adsorption capacity at 88.14% MB removal under specific conditions. ANOVA analysis confirmed the significance of the quadratic model, with a p-value of 0.0222 and R^2 = 0.9438. In conclusion, the results demonstrated the efficiency of PKS-based activated biochar as an adsorbent for MB removal in comparison to other commercial adsorbents.

Author keywords

adsorption; biochar; methylene blue dye; microwave heating; Palm kernel shell

Indexed keywords

Engineering controlled terms

Adsorbents; Alumina; Ceramic materials; Cost effectiveness; Dyes; Environmental technology; Inert gases; Removal; Shells (structures); Silica; Stretching; Wastewater treatment

Engineering uncontrolled terms

Biochar; Cost-effective approach; Domestic microwave ovens; Dye removal; Heating time; Inert atmospheres; Methylene Blue; Methylene blue dye; Microwave-heating; Palm kernel shells

Engineering main heading

Adsorption; Fourier transform infrared spectroscopy; Microwave heating

Funding details

Details about financial support for research, including funding sources and grant numbers as provided in academic publications.

Funding sponsor	Funding number	Acronym
International Islamic University		

Funding text

The authors would like to thank the International Islamic University for providing the facilities and support.