Dual-optimization of pyrolitic parameters of biochar for application as a sustainable effluent biofilter

- D. O. Masara,
- P. T. Cherop,
- E. E. Osore &
- H. B. Masinde

Abstract

Biochar is a carbonaceous solid produced through pyrolyzing biomass under limited oxygen. It is widely recognized for its role in soil improvement, carbon sequestration, and contaminant adsorption. This study optimizes biochar production from bagasse, bamboo, and eucalyptus for industrial effluent treatment. Mixed biomass sources are explored, and the effect of pyrolytic parameters on biochar performance is examined. Experimental trials evaluated the impact of temperature, residence time, heating rate, and particle size on the Brunauer–Emmett–Teller (BET) surface area and Barrett-Joyner-Halenda (BJH) porosity. Bamboo biochar showed the highest activation, with surface areas > 700 m^2/g and porosity ~ 0.85 cm^3/g. Bagasse showed high porosity of 1.02 cm^3/g but required careful temperature regulation due to its rapid devolatilization. Eucalyptus exhibited a moderate surface area of 333 m^2/g with stable pore distribution. Thermal modeling using the transient heat conduction equation confirmed feedstock-specific heating behavior, aligning with experimental pore formation trends. These thermal gradients agreed with observed experimental trends, validating the role of feedstock-specific heat transfer in pore formation. Overlay plots for dual-response optimization (BET ≥ 250 m^2/g, porosity ≥ 0.5 cm^3/g) confirmed that bamboo is the most adaptable feedstock, with bagasse and eucalyptus offering unique advantages, since they can be tailored. The development of a multistage biofilter is recommended to exploit the distinct features of the three feedstocks.