Batch mode adsorption of a Cationic Dye on a Biomass Waste: Modeling and optimization of operating conditions using experimental design

BENSEDJAD assia[1], OUAZANI fouzia[1], BENOUIS khedidja[1], BOUANANI Meriem[1]

Laboratory of Process Engineering, Materials and Environment,
Faculty of Technology, University of Djillali Liabes, PO Box 89,
Sidi Bel Abbes 22000
Algeria.

Abstract

The treatment of wastewater generated by the industries is challenging due to various xenobiotic and dangerous pollutants, notably multi-category carcinogenic dyes. Existing conventional treatment methods employed in developed countries are costly, prompting the search for a suitable alternative to achieve sustainable and economically viable development. Researchers interested in sustainable development widely adopt the biosorbent adsorption method to effectively remove micropollutants from water. This involves using low-cost materials as an alternative to dangerous and expensive products.

This work focuses on the modeling of adsorption in Batch mode, with the main objective being to study the adsorption of Methylene Blue (MB), a cationic dye, on Grape Pomace (GP), an oenological waste. The influence of parameters such as dye concentration, biosorbent mass, adsorption time, and pH of the MB solution are studied for process optimization. The acquired results undergo a comprehensive analysis employing kinetic models, including the pseudo-first and second order, and the intra-particle diffusion model. Furthermore, the results are subjected to optimization through the application of the Box-Behnken design.

The results of the kinetic analysis reveal that the pseudo-second-order kinetic model describes the adsorption of MB on GP more appropriately with a coefficient of determination R^2=0.999 compared to pseudo-first-order and intra-particle diffusion models. The application of experimental design methodology (Box-Behnken model) allows to estimate and optimize the adsorption capacity to 37.38 mg/g of MB removal at pH=5, m=75mg, and C=40 mg/L of factors studied with a reduced number of experiments. The results of both approaches confirm the effectiveness of using oenological waste in wastewater treatment, enabling precise control of parameters influencing adsorption.

Keywords:
Biosorbent, Batch Mode, Modeling, Grape Pomace, Methylene Blue, Experimental Design.