Sorption of Basic Cationic Dye onto Municipal Waste Biochar Equilibrium and Thermodynamic Study

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In the present world, environmental pollution is a global challenge closely linked with rapid industrialization. Contamination of the aquatic eco-system with discharges of industrial dye effluents is a critical environmental issue. The high cost of conventional treatments to remove dyes is a challenge both economically and technically. Hence, this study determined the removal of a synthetic basic cationic dye (methylene blue) in aqueous solution using municipal waste biochar as a low-cost sorbent derived from biosolids pyrolysis. Methylene blue is used as a model dye to study the effectiveness of different sorbents since it is rapidly adsorbed by sorbents. The effect of different experimental parameters such as contact time, pH, adsorbent dosage and temperature were determined to measure the dye removal efficiency. The adsorption isotherms of the process were evaluated using the data obtained from above experiments. Biochar was prepared through pyrolysis of sludge at 300 °C for ½ h with a constant heating rate of 10 °Cmin^{-1}.The results indicate that the optimum contact time for dye removal is 1.5 h, optimum pH and dosage ranges from pH 1-10, and 10-40 mg/L, respectively. All these optimum conditions showed a dye removal efficiency above 90%. The best-fitted isotherm models to describe the methylene blue adsorption onto biochar were Dubinin-Radushkevich, Langmuir and Temkin which gave R^2 values over 0.990. According to thermodynamic study, the sorption process was spontaneous and endothermic. The surface area of biochar was 82 m^2/g. Key functional groups identified through Fourier Transformed Infrared Spectroscopy (FTIR) analysis were phenolic, alcohol and carboxylic groups. Generally, biochar derived at low pyrolytic temperature preserves functional groups responsible for higher removal efficiencies as resulted in this study. Based on experimental results, the biochar derived from municipal waste biosolids is an effective sorbent for methylene blue removal which can be further experimented with other industrial cationic dyes.

Keywords: Isotherm, Methylene blue, Modeling, Pyrolysis, Sludge