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Removal of Crystal Violet Dye in Textile Wastewater Using Rice Husk Biochar

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Abstract

Crystal Violet Dye (CVD) is a water-soluble, hazardous organic dye that causes adverse health issues and environmental pollution. This dye was mostly added to wastewater by the textile industries. Treatment of CVD-contained wastewater has become a great challenge due to high investment and operating costs and inefficiency in dye removal of conventional methods such as biological degradation and chemical oxidation. So, the main purpose of this study is to investigate the CVD removal ability of Rice Husk Biochar (RHB). The experiment procedure was designed to determine the influence of initial CVD concentration, adsorbent dosage, pH, contact time, and temperature on dye removal. RHB was prepared by pyrolysis process at 700^{o} C for 3h at a constant heating rate of 10^{o} C min^{-1} in a muffle furnace. Adsorption of CVD by RHB was verified by performing Fourier Transform Infrared spectroscopy. The concentration of the remaining dye after adsorption studies was calculated using Ultra-Violet visible spectroscopy. According to the results, the dye removal efficiency increased with the RHB amount, but the rate of this increment decreased at higher RHB dosages. The highest dye removal efficiency of 97.33% was recorded at 1.5 g RHB amount. In the effect of initial CVD concentration, the efficiency increased up to 600 mg/l and then decreased and the maximum removal efficiency was 96.77%. pH value has no significant effect on dye removal and the highest efficiency of 97.3 % was recorded at pH 4. Further, as the contact time increased, the dye removal increased until it reached an equilibrium state at 60 minutes with 92.03% efficiency. Moreover, when raising the temperature, the adsorption of CVD by RHB marginally increased. According to the kinetic studies, the experimental data followed pseudo-second-order kinetic models than pseudo-first order. Further, adsorption equilibrium data well fitted both Freundlich and Langmuir isotherm models so that it can be assumed that both monolayer and multilayer adsorption of CVD in RHB surface. Thermodynamic parameters such as Gibbs free energy and enthalpy change were calculated, and all values were recorded as negative implying adsorption was favorable and spontaneous and the process was exothermic. In conclusion, the optimum dye removal was recorded at 35^{0} C and pH 4 with an initial dye concentration of 600 mg/L and adsorbent dosage of 1.5 g. Thus, this study concluded that RHB could be utilized as a cost-effective, eco-friendly, and affordable adsorbent for the removal of CVD from wastewater with over 90% dye removal efficiency.

Key words: Crystal violet dye, Rice husk biochar, Textile industry, Adsorption