# Bench-Scale Fixed-Bed Column Study for the Removal of Dye-Contaminated Effluent Using Sewage-Sludge-Based Biochar


## ABSTRACT

Batik industrial effluent wastewater (BIE) contains toxic dyes that, if directly channeled into receiving water bodies without proper treatment, could pollute the aquatic ecosystem and, detrimentally, affect the health of people. This study is aimed at assessing the adsorptive efficacy of a novel low-cost sewage-sludge-based biochar (SSB), in removing color from batik industrial effluent (BIE). Sewage-sludge-based biochar (SSB) was synthesized through two stages, the first is raw-material gathering and preparation. The second stage is carbonization, in a muffle furnace, at 700 ◦C for 60 min. To investigate the changes introduced by the preparation process, the raw sewage sludge (RS) and SSB were characterized by the Brunauer–Emmett–Teller (BET) method, Fourier-transform infrared spectroscopy (FTIR), and scanning electron microscopy. The surface area of biochar was found to be 117.7 m2/g. The results of FTIR showed that some functional groups, such as CO and OH, were hosted on the surface of the biochar. Continuous fixed-bed column studies were conducted, by using SSB as an adsorbent. A glass column with a diameter of 20 mm was packed with SSB, to depths of 5 cm, 8 cm, and 12 cm. The volumes of BIE passing through the column were 384 mL/d, 864 mL/d, and 1680 mL/d, at a flow rate of 16 mL/h, 36 mL/h, and 70 mL/h, respectively. The initial color concentration in the batik sample was 234 Pt-Co, and the pH was kept in the range of 3–5. The effect of varying bed depth and flow rate over time on the removal efficiency of color was analyzed. It was observed that the breakthrough time differed according to the depth of the bed and changes in the flow rates. The longest time, where breakthrough and exhausting points occurred, was recorded at the highest bed and slowest flowrate. However, the increase in flow rate and decrease in bed depth made the breakthrough curves steeper. The maximum bed capacity of 42.30 mg/g was achieved at a 16 mL/h flowrate and 12 cm bed height. Thomas and Bohart–Adams mathematical models were applied, to analyze the adsorption data and the interaction between the adsorption variables. For both models, the correlation coefficient ($R^2$) was more than 0.9, which signifies that the experimental data are well fitted. Furthermore, the adsorption behavior is best explained by the Thomas model, as it covers the whole range of breakthrough curves.