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Removal of Caffeine Using Steam Activated Tea Waste Biochar from Aquatic Environment

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Caffeine (CFN) is used as cerebral, cardiac, respiratory stimulant drugs in human and it is considered as an emerging contaminant in the environment, which recently reports frequently in environmental waters. The present study aimed to remove CFN from aqueous solution using steam activated tea waste biochar derived at 700 °C (TWBC-SA) in various environmental conditions. TWBC-SA was obtained by slow pyrolysis process at laboratory conditions and the temperature increased rate was 7 °C/min during the pyrolysis. The TWBC-SA contained 82.37% of C, 2.07% of H, 11.57% of O, 3.89% of N, and 0.10% of S. Surface area of TWBC-SA was reported as 576 m^2g^{-1} with a well-developed porous structure. The edge experiment was conducted at varying pH from 3 to 10, the kinetic studies were conducted with different contact time up to 24 h and the isotherm experiment was carried out at different initial CFN concentrations (10-300 mg L^{-1}) at 1 g L^{-1} dosage and 25 °C. The analysis of CFN in aqueous solution was performed using UV-Visible spectrophotometer at λ_{max} 272 nm with Quartz cuvette. The pH edge experiment showed that the maximum adsorption of CFN by TWBC-SA was at pH 3.5. After 12 hours of contact time, the exhibited maximum adsorption capacity was 15.39 mg g^{-1}. The kinetic data well fitted with the Elovich model and it described the involvement of chemical forces in the adsorption of CFN with initial adsorption rate of 56 mg g^{-1} min^{-1}. Temkin and Freundlich isotherms were the best-fitted models with the experiment data. The most fitted model was Freundlich with R^2 of 0.96 and chi-square of 2.183. The Freundlich model indicated that the adsorption of CFN onto the TWBC-SA is favorable. Overall, the experiments data suggested the incorporation of CFN onto TWBC-SA mainly driven by the chemical forces. Thus the TWBC-SA can be used as potential remediate in the removal of CFN from the aquatic environment.

Keywords: Emerging contaminants, caffeine, carbon material, adsorption, chemisorption