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Removal of Ciprofloxacin from aquatic environments using Pristine and KOH activated waste rice biochar

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Ciprofloxacin (CPX) is an antibiotic used to treat many bacterial infections and is considered as a water pollutant, which induces antibiotic resistance. This study aimed to remove CPX from water using pristine (WRBC-P) and KOH-activated (WRBC-A) waste rice biochar derived at 500 ˚C. WRBC-P was prepared by pyrolysis of expired rice grains at a 5 ˚C/min heating rate. KOH activation was carried out using WRBC-P to obtain WRBC-A. Both biochar samples were characterized using Fourier Transform Infrared Spectroscopy (FTIR) and Scanning Electron Microscope (SEM). The data indicates that the activation improves the pore structure and the surface area of biochar. Removal of CPX by both biochar variants was studied in batch experiments. The edge experiments were conducted by varying the pH from pH 3 to 10, kinetics experiments at different time intervals up to 24 h and the isotherm studies at different initial CPX concentrations (2-25 mg/L) in the presence of 1 g/L dosage of biochar at 25 ˚C. Variations in CPX concentrations before and after adsorption studies were determined using UV-visible spectroscopy measuring absorbance at 277 nm λ_{max} using a Quartz cuvette. The maximum adsorption capacity of CPX was observed at pH 7.3 for both WRBC-P and WRBC-A. After 12 hours of equilibrium time, the maximum adsorption capacities were 1.45 mg/g and 6.15 mg/g for WRBC-P and WRBC-A respectively. The fractional power model was the best-fitted model for the kinetic data obtained for both WRBC-P and WRBC-A. This explains that the rate of the adsorption of CPX on biochar depends on the concentration of CPX to non-integral power. This reflects that the CPX adsorption takes place via a complex mechanism with intermediate formation. Isotherm data confirms that the adsorption of CPX is a two-way process for both WRBC-P and WRBC-A. Hill isotherm model was fitted with cooperative binding between CPX and biochar showing a monolayer formation for the first part of the data set. After that, the Freundlich model was equipped with the multilayer adsorption of CPX on the biochar surface. Overall, experimental data suggested that the incorporation of CPX onto both WRBC-P and WRBC-A is mainly driven by both chemical and physical forces. CPX adsorption was a favorable process at room temperature and in the 7-8 pH range after 12 hours of contact time. WRBC-A demonstrated four times higher CPX removal capacity than that of WRBC-P indicating KOH activation as an efficient route to improve the adsorption capacity of biochar for the removal of CPX.

Keywords: Ciprofloxacin, Biochar, Adsorption, Waste rice, Isotherm