Study of the Effect of Incorporating a Preconditioning Step for the Adsorption of Methylene Blue from Water by Douglas fir Biochar

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Three major kinetic processes governing adsorbate uptake by an adsorbent such as biochar (BC) has been defined as external mass transfer, intraparticle diffusion (IPD) and mass action. In the usual methodology of batch adsorption, where the solution containing the adsorbate is directly introduced to the dry biochar, the entire pore space may not be accessible as the pore interior is not well hydrated. The presented work evaluates the effect of incorporating a preconditioning step where the BC is shaken with a selected organic solvent as a means of hydrating the hydrophobic pore interior. It is followed by its equilibration with de-ionized (DI) water to replace the preconditioning solvent. The process provides a BC with hydrated pores with a 'sample like' solvent. Solvents utilized for preconditioning were methanol (MEOH), acetone (ACE), acetonitrile (ACN) and DI followed by equilibration with DI. Sorption characteristics of pre-conditioned BC (PBC) was compared with that of non-preconditioned (NBC). The adsorption process was not significantly influenced by pH variations and the predominant sorption mechanisms were concluded to be π-π electron donor acceptor (EDA) interactions and pore filling. Adsorption capacity showed a stochastic dependence with increasing contact time for the preconditioned biochar in contrast to the NBC. Both PBC and NBC fitted well with the PSO behavior. Sorption capacities for all PBC were lower than NBC which can be attributed to pore blockage. In contrast to NBC, a clear rate determining step was not observed by the intraparticle diffusion model for PBC. Though the Freundlich isotherm model was fitted well by the NBC, the PBC sorption did not fit into the isotherm models studied such as Langmuir, Freundlich, Temkin, Sips and Redlich- Peterson. An enhancement in kinetics for DI PBC was observed at the compromise of ill-fitting isotherm patterns and uptake behavior.

Keywords: Douglas fir Biochar; Methylene Blue; Preconditioning; Kinetic mechanisms

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