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Kinetics and Thermodynamics of Nitrate Adsorption by Biochar

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Abstract

High concentration of nitrate in surface and ground water has been a universal source of water pollution, eutrophication and soil acidity. Adsorption has been widely used for the removal of contaminants from wastewater and soils. It has a controlling influence on anion mobility, transport and bioavailability. Evaluating the adsorption kinetics and thermodynamics of nitrate sorption of biochar is a prerequisite for limiting nitrate pollution. Four biochar samples; Maize cob biochar (MCB), rice husk biochar (RHB), cow dung biochar (CDB) and poultry litter biochar were subjected to batch sorption experiment, adsorption kinetics and thermodynamic studies. Data obtained were fitted into the linear forms of isotherm and kinetic models. Least square regression analysis was used to test the best fitting Isotherm and kinetic models. Results obtained for the Langmuir adsorption isotherm revealed that only MCB and PLB had the ability to adsorb nitrate with maximum quantity adsorption of 73.915 and 133.887 mgg^{-1}. The Freundlich and Dubunin-Radushkevich models were the best fitting models for describing NO_3 adsorption on to PLB ($R^2 = 0.998$) while nitrate adsorption onto MCB was best described by the Freundlich adsorption isotherm with an R^2 value of 0.9999. Thermodynamics of nitrate adsorption onto the biochar samples revealed an exothermic, thermodynamically feasible and spontaneous process onto MCB, PLB and RHB with increasing disorderliness at 25, 35 and 45 °C except on the adsorption of nitrate onto CDB were an endothermic, nonspontaneous adsorption were observed across all the temperatures. Similarly, adsorption kinetics indicated better fitting of the adsorption data onto the linear form of the pseudo second order kinetic (PSOK) model. However, pseudo first order kinetics model (PFOK) sufficiently described nitrate adsorption on to PLB ($R^2 = 0.966$) and MCB ($R^2 = 0.871$) but with higher SSE compared to that of the PSOK. Lower R^2 values were recorded by the intra particle diffusion and Elovich kinetic models for nitrate adsorption onto all biochar samples and ruled out the possibility of intra particle diffusion and chemical adsorption being the rate controlling step, suggesting that nitrate adsorption onto the biochar samples involved weak van der waal's forces probably an outer sphere complexation.

Keywords: Biochar, eutrophication, kinetic models , nitrate pollution

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