Goldschmidt 2023 Abstract
https://doi.org/10.7185/gold2023.14568

Adsorptive removal of perfluorooctanoic acid (PFOA) using peanut husk-derived magnetic biochar: Isotherm, kinetics, and sorption mechanism

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Perfluorooctanoic acid (PFOA) is a synthetic organic pollutant of per-and polyfluoroalkyl substances (PFAS) family that has sparked concern due to its widespread presence in the environment and associated health risks. Numerous remediation approaches have been researched to remove this contaminant, with adsorption emerging as one of the most effective process. Reportedly, adsorbents like clay, nanomaterials, ion exchange resin polymer, and graphene remove PFOA successfully. Out of these, biochar has received considerable attention due to its ability to remove organic and inorganic contaminants while lowering production costs. Biochar is made from agricultural waste, which maximizes waste usage while minimizing the loss of biomass resources. However, biochar has certain disadvantages, such as the difficulty in extracting it from the solution. To facilitate the efficient adsorption of PFOA and regeneration of the adsorbent, magnetic biochar (MBC) was synthesized in this study by pre-modifying peanut husk with ferric chloride and pyrolyzing the pre-treated material at three different temperatures (300 °C, 600 °C, and 900 °C). SEM, FTIR, XRD, BET surface area, and point of zero charge were used to characterize the morphological and physicochemical attributes of synthesized MBC. Preliminary findings revealed that $MBC_{600°C}$ had greater removal efficiency than $MBC_{300°C}$ and $MBC_{900°C}$. Batch experiments were performed to evaluate the sorption mechanism and adsorption characteristics, including sorption kinetics, sorption isotherm, thermodynamics, and the effect of solution pH. For kinetic data, first and pseudo-second-order reaction models were selected, with the latter describing the sorption kinetic better. It demonstrated a maximum removal efficiency of >95% and an equilibrium time of 120 minutes for $MBC_{600°C}$. Similarly, the sorption isotherm demonstrated that the Freundlich model was the best-fit model. It was also observed that with an increase in solution pH, the adsorption of PFOA was reduced. This was due to an increase in electrostatic repulsion between negatively charged functional groups and anionic PFOA headgroup. Lastly, the regeneration study showed that $MBC_{600°C}$ could maintain high adsorption capacity up to the fourth cycle. The study concluded that $MBC_{600°C}$ could be a promising adsorbent for removing PFOA from an aqueous solution.