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SUSTAINABLE IRON-MODIFIED BIOCHARS FOR THE ADSORPTION OF CONVENTIONAL AND EMERGING CO-EXISTING CONTAMINANTS IN SHALLOW URBAN GROUNDWATER

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Shallow groundwater impacted by sewage inputs can exhibit mixed contaminant signatures associated with urban activities. In the shallow part of the Bauru Aquifer System (Bauru, Brazil), groundwater monitoring between December 2023 and August 2025 revealed nitrate concentrations reaching up to 25 mg/L (as N), and total PFAS concentrations of 4.2 to 194 ng/L. Detected PFAS included both short-chain (PFBA, PFPeA, PFHxA, PFBS) and long-chain (PFHxS, PFOS, PFHpA, 6:2 FTS, PFOA) compounds. Given the importance of this aquifer for water supply, sustainable treatment strategies are needed to address the complex contamination by integrating material design with site-specific hydrogeochemical conditions. Iron-modified biochars (Fe-BC) produced from sugarcane bagasse, a low-cost waste product generated locally, could be a promising solution, as they can remove both organic and inorganic contaminants. In preliminary experiments, Fe-BC pyrolyzed at 300°C (Fe-BC3, pH_{PZC} = 4.0, BET = 5.9 m^2g) effectively removed nitrate, PFOS, and PFOA, but exhibited limited removal of PFBA, a short-chain PFAS. To enhance adsorption performance, especially for short-chain PFAS, an iron-modified biochar pyrolyzed at 600°C (Fe-BC6, pH_{PZC} = 5.8, BET = 17.1 m^2g) was synthetized. Batch adsorption experiments using single-compound PFBA and PFOS solutions revealed that Fe-BC6 effectively adsorbed both compounds. X-ray diffraction indicated hematite (Fe_2O_3) as the dominant iron oxide phase in Fe-BC3 and magnetite (Fe_3O_4) in Fe-BC6. The enhanced adsorption of PFBAs could be attributable in part to the magnetite phase in Fe-BC6, which may contain reactive Fe sites that promote interactions with anionic PFAS at the solid-solution interface. This finding provides a conceptual basis for designing combined reactive materials with contaminant-specific retention mechanisms.