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# Evaluating a Regenerable Montmorillonite–Polysulfone Composite for Passive Uranium Flux Measurement

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Accurate assessment of uranium (U) transport in groundwater requires evaluation of mass flux rather than concentration alone. The performance of passive flux meters (PFMs) largely depends on the durability and adsorption efficiency of the packing material. In this study, a mechanically stable granular composite sorbent was fabricated by immobilizing montmorillonite within a polysulfone matrix (MPS) and evaluated for its applicability in groundwater uranium flux monitoring. The optimized composition (4 wt% montmorillonite) produced spherical beads that maintained structural integrity while providing effective adsorption capacity. Equilibrium experiments demonstrated favorable adsorption behavior consistent with the Langmuir model, yielding a maximum capacity of 278.9 μg/g. Kinetic analysis showed that both pseudo-first-order and pseudo-second-order models adequately described the adsorption process ($R^2 > 0.97$), indicating combined surface interaction and diffusion-controlled mechanisms. Regeneration tests further confirmed stable adsorption–desorption performance over repeated cycles. Under continuous-flow column conditions (influent U = 1.2 mg/L; Darcy velocity = 0.4 m/day), a stable pre-breakthrough region was identified within 3 pore volumes ($C/C_0 \leq 0.1$), from which a conservative working capacity of 0.014 mg/g was defined. Field-scale estimation based on this working capacity suggests that deployment periods in a monitoring well may range from several days to approximately three weeks depending on groundwater velocity and uranium concentration. These findings indicate that MPS is a robust and regenerable sorbent for time-integrated uranium flux monitoring using PFMs, with potential for future integration with tracer-based approaches to assess both contaminant and water flux.

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