Leveraging Watershed Wetlands to Optimize Phosphorus Management Strategies in Lake Erie Basin

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Wetlands offer a natural solution to mitigate nutrient loading in water bodies such as Lake Erie, where excessive phosphorus (P) drives harmful algal blooms (HABs). Constructed and restored watershed wetlands play a critical role in reducing nutrient loads, but their effectiveness can vary based on soil characteristics, hydrology, vegetation, and management practices. To optimize P retention, this study combines three years of field monitoring and mesocosm experimentation to develop and evaluate adaptive nutrient retention strategies based on adjusting hydroperiods, vegetation management, and amendment usage. Across both field and mesocosm settings, results show a consistent reduction of dissolved P concentrations by >50% from influent to effluent waters, with removal efficiency improving with increased hydraulic residence time. Mesocosm experiments demonstrate that varying hydraulic loading rates and hydropatterns can increase P removal efficiency by up to 37%, nearly tripling mass of P retained compared to standard, static pumping regimes. Release of P through natural senescence or the harvest of vegetation at the end of the growing season was minimal (5-7x less) compared to the amount retained by the mesocosm system during a single pumping event. At the demonstration site, wetland soils have acted as a sink for phosphorus. Spatial and temporal variability in P storage is linked to inundation patterns and landscape gradients, highlighting the interplay between hydrologic dynamics and ecological structure. Current efforts are concentrated on analyzing the results of scaled P-sequestering technologies deployed in strategically vital areas of demonstration site, aiming to extend wetland lifespan and optimize P capture and permanent removal. These findings demonstrate a scalable approach to long-term monitoring and adaptive management that optimizes nutrient retention in watershed wetlands, improving regional water quality and mitigating HABs in Lake Erie basin.