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Translating Deltaic Hydrogeochemistry into Eco-Hydrological Solutions through Practice-Driven Partnerships

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Securing freshwater and protecting blue carbon in climate-vulnerable deltas requires translating fundamental hydrogeochemical baselines into scalable eco-hydrological solutions through robust academic-industry partnerships.

In the Indian Sundarbans, our initial profiling established process-based baselines of cyclonic aquifer salinization. By quantifying severe seawater mixing and critical soil deflocculation risks, we defined the exact geochemical tipping points where tidal inundation triggers both agricultural collapse and subsurface degradation.

Beyond immediate freshwater scarcity, this aggressive salinization destabilizes the region's socio-ecological framework and degrades critical blue carbon sinks. Altered redox conditions in salt-intruded soils disrupt organic carbon preservation, threatening to shift coastal wetlands from carbon sinks to greenhouse gas emission sources. To address this our work transitions from impact assessment to active eco-hydrological remediation through targeted academic-industry collaborations. Building on these molecular-scale baselines, partnerships with engineering and environmental sectors aim to design large-scale surface water rehabilitation and managed aquifer recharge systems. We utilize our established geochemical parameters not just as historical markers, but as dynamic monitoring tools to evaluate remediation performance. These partnerships frame fundamental biogeochemical questions specifically, how restored freshwater gradients and managed redox integrity influence soil carbon stabilization within realistic industrial land-management scenarios. Co-developing these workflows ensures that interventions do not merely dilute salinity, but actively restore the biogeochemical filtration capacity of the deltaic soil.

In the presentation, we will detail the specific hydrogeochemical indices to define these vulnerability tipping point. This trajectory demonstrates how fundamental hydrogeochemistry can be converted into actionable frameworks. By connecting localized salinity and soil metrics to broader carbon cycles and eco-hydrology, these partnerships link ecosystem protection, freshwater resilience, and analytical innovation directly to global net-zero objectives.