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Soil porewater monitoring for enhanced rock weathering MRV using SATuration–Centrifugation (SAT-C)

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Enhanced rock weathering (ERW) is a rapidly expanding carbon dioxide removal strategy, with commercial deployments in at least 14 countries[1]. ERW accelerates silicate weathering by applying crushed rock to agricultural soils, generating alkalinity and promoting long-term CO_2 sequestration. The credibility and scalability of carbon removal markets depend on monitoring, reporting, and verification (MRV) frameworks that are both scientifically rigorous and economically feasible at scale.

While solid-phase measurements are increasingly used to quantify ERW-derived carbon removal[2], soil porewater monitoring is required to verify ERW credits and quantify ionic species relevant to strong acid weathering[3]. However, commonly used methods such as rhizons and suction lysimeters are constrained by soil moisture availability and poorly defined sampled volumes, often resulting in low sample yields, seasonal gaps, and reduced comparability. Restricting sampling to high-moisture conditions may bias solute flux estimates, given the tight coupling between soil moisture and solute transport[4].

Here we present an extended evaluation of SATuration–Centrifugation (SAT-C), a practical porewater extraction method that recovers porewater from intact soil cores independent of in situ moisture. SAT-C combines controlled saturation with centrifugation to generate sufficient sample volume for major ion analysis and bicarbonate alkalinity estimation via charge balance.

We deployed SAT-C across multiple ERW monitoring sites in Ontario, Canada, and compared porewater chemistry with co-located rhizon time series. Across hundreds of samples, SAT-C and rhizon data show strong agreement in major cations (Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}), and anions (Cl^{-}, SO_4^{2-}, NO_3^{-}). Critically, SAT-C enables reliable fluid sampling during periods when rhizon recovery declines, improving temporal continuity and seasonal representativeness. Because cores remain intact, SAT-C also enables paired solid-phase analyses, such as exchangeable cations, strengthening mass-balance interpretations.

Our results show reliable acquisition of essential cation and anion data from a known soil volume collected quickly and affordably as depth-specific cores. SAT-C is reproducible and cost-effective, improving the robustness and comparability of porewater measurements for ERW MRV across heterogeneous field conditions.

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