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Tracing Carbon Loss in Small Agricultural Tributaries: Implications for Enhanced Rock Weathering

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Enhanced rock weathering (ERW) is a carbon dioxide removal (CDR) strategy that involves applying crushed silicate or carbonate rocks to land, typically agricultural fields. These rocks chemically react with atmospheric CO_2 and water to produce dissolved inorganic carbon (DIC) and alkalinity, primarily in the form of bicarbonate and associated cations. For the method to durably sequester carbon, these weathering products must travel to the ocean where they have a residence time of >100,000 years. However, as the products travel from field to ocean through the riverine system, there are multiple biotic and abiotic processes that can convert DIC back to CO_2 or consume alkalinity — such as CO_2 degassing, calcite precipitation, and aquatic photosynthesis. Loss of both DIC and alkalinity prior to reaching the ocean affects net CDR.

Previous studies quantifying ERW-product loss have focused on major, gaged rivers. We hypothesize that substantial losses occur earlier—within small, un-gaged agricultural tributaries—where DIC and nutrient concentrations are highest. By ignoring this section of the riverine transport pathway, it is possible the ERW community is overlooking the river sections where a majority of the losses occur.

To test our hypothesis and fill the knowledge gap, we instrumented and routinely sampled a field tile drain and the associated drainage channel within a corn-soy agricultural area near Champaign, IL. Our data indicate that the channel was highly productive, with unexpectedly high rates of aquatic photosynthesis. This finding is noteworthy for ERW because aquatic photosynthesis can reduce DIC through carbon fixation and alter alkalinity through biological uptake of cations and nutrients. By focusing on a small agricultural drainage channel—an overlooked but potentially critical segment of the field-to-ocean pathway—our study will provide essential data and knowledge to better evaluate the long-term carbon sequestration potential of ERW.