Climate win-win: Study quantifies benefits of enhanced weathering

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Basalt is applied to fields at the University of Illinois Energy Farm as part of an enhanced weathering project. Credit: Institute for Sustainability, Energy, and Environment (iSEE)

Applying ground-up silicate rock to Midwestern farm fields can capture significant amounts of carbon dioxide and prevent it from accumulating in the atmosphere, according to a new study that successfully quantified those climate benefits for the first time.

Working with Eion Corp., researchers at the University of Illinois Urbana-Champaign and the Leverhulme Center for Climate Change Mitigation (LC3M) developed a new method to calculate the CO_2-reduction potential of basalt rock amendments applied to cropland soil, a process known as enhanced weathering.

Traditional row-crop agriculture releases sizable amounts of soil-derived carbon to the atmosphere as CO_2, a greenhouse gas that is a primary driver of climate change. With enhanced weathering, silicate rock is applied to farmland to capture that carbon before it reaches the atmosphere. As the rock weathers, calcium and magnesium are released and react with dissolved CO_2 to produce bicarbonate, essentially locking up the gas and redirecting it harmlessly into groundwater.

Quantifying its carbon-capture potential, however, has been a challenge—until now. The Illinois team was able to calculate both the weathering rate and carbon dioxide reduction potential of the basalt rock amendments applied to maize and miscanthus fields. Those factors are critical for efforts to optimize carbon sequestration and for farmers hoping to earn carbon credits.

"In addition to reducing emissions, we desperately need effective ways to draw down atmospheric carbon dioxide. Our results suggest that basalt application to farms could be a win-win for farmers and for the planet, improving yields and drawing down CO_2," said study co-author Evan DeLucia, Director Emeritus at the Institute for Sustainability, Energy, and Environment (iSEE), G. William Arends Professor Emeritus of Plant Biology, and Co-Investigator at the Center for Advanced Bioenergy and Bioproducts Innovation (CABBI) at Illinois.

The breakthrough—the result of a five-year study at the Illinois Energy Farm—was published in *Global Change Biology*. The study was led by DeLucia and Ilsa Kantola, Research Scientist at iSEE and the Carl R. Woese Institute for Genomic Biology (IGB).

The work is part of iSEE's partnership with the Leverhulme Center at the University of Sheffield in the United Kingdom, which is investigating enhanced weathering for carbon dioxide removal in field sites around the world: Malaysia, Australia, the U.K., and the United States.

In this case, researchers repeatedly applied finely-ground basalt on twin fields at the Energy Farm for four years—one field with a maize/soybean crop rotation and the other with Miscanthus x giganteus, a perennial grass that is emerging as a productive bioenergy crop to replace fossil fuels.

Grinding the basalt accelerates a natural weathering process that involves two chemical reactions. First, atmospheric CO_2 dissolves in rainwater to create carbonic acid. Then, the acid reacts with the rock dust in the soil to form bicarbonate, a soluble compound that leaches with soil water; that redirects the CO_2 from the atmosphere to the water cycle, where it can pass harmlessly into waterways and potentially help fight ocean acidification. Basalt contains both calcium and magnesium as well as phosphorus and minor nutrients that are released during weathering and benefit soil fertility.

The Illinois team calculated the CO_2 reduction and weathering rate of the basalt by measuring the change in rare earth elements in the soil with the addition of basalt and comparing it to the calcium and magnesium in the system. The rare earth elements are "sticky," building up in the soil in tiny amounts as more basalt is applied, and calcium and magnesium are released by weathering, with some taken up by the crops.

The difference in rare earth elements indicates how much basalt, and therefore how much calcium and magnesium, has been applied; and the difference between the expected amount of calcium and magnesium and the actual amount in the soil tells researchers how much has been consumed by reactions in the soil.

The calculations showed that enhanced weathering reduced net carbon loss to the atmosphere by 42% in maize plots. Paired with conservation tillage or cover crops, the basalt application could turn maize into a net carbon sink.

In miscanthus plots, which already stored more CO_2 than they emitted before the addition of basalt, enhanced weathering more than doubled carbon storage. The finding adds to the potential climate benefits of this renewable bioenergy crop, one of three targeted by CABBI in its U.S. Department of Energy-funded work.

Carbon dioxide removal methods are a critical part of climate mitigation strategies, and as social and political efforts to reduce carbon emissions to the atmosphere are delayed, pressure is growing to implement these strategies soon.

Farmers, landowners, and others seeking carbon credits all want to know how much basalt rock to apply and how long the effect will last, both of which depend on the composition of the rock and the environmental conditions where it is applied.

"As we look for new ways to offset carbon emissions, we need to be able to quantify those carbon savings to better compare our options," Kantola said.

More information: Ilsa B. Kantola et al, Improved net carbon budgets in the US Midwest through direct measured impacts of enhanced weathering, *Global Change Biology* (2023). DOI: 10.1111/gcb.16903

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