Potential for additional climate stabilization from enhanced rock weathering

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The enhanced weathering (EW) of basalt in cultivated soils is a promising strategy for atmospheric CO_2 removal. The impacts of soil alkalization and nutrient release during the mineral dissolution of basalt on the biogeochemistry of agricultural soils may add to the climate stabilization effect of inorganic CO_2 sequestration. We combined empirical and modeling approaches, including a process-based biogeochemical model (DAYCENT) and a land-atmosphere coupled model (CLM5), for the cross-scale determination – from field to global – of the impacts of basalt amendments on cropland N cycling, attributing causality and evaluating the potential of EW in climate mitigation schemes. Six years of experimental basalt additions increased soil pH and consistently reduced N_2O emissions from heavily-fertilized maize (*Zea mays*) and low-fertilized miscanthus (*Miscanthus x giganteus*). An in-silico assessment of the biogeochemical interactions driving ecosystem N dynamics indicate that basalt additions reduced annual N_2O emissions by 16% in maize and 9% in miscanthus, and lowered the N_2O emission factor (i.e. amount of N fertilizer released to the atmosphere in the form of N_2O) by 17% and 11% respectively, adding to the climate mitigation potential of EW. Predicted decreases in N_2O emissions responded to pH-induced increases in the N_2:N_2O ratio of denitrification, with minor contributions from P additions (an integral component of basalt) on N immobilization. Further, model results showed marginal increases in yields and the N use efficiency (i.e. fertilizer-N recovered in crop production) of basalt amended crops, but enhanced P availability sustained the long-term productivity of crops with high nutrient requirements. At the global scale, EW deployment on ~ 50% of global croplands could reduce soil N_2O and NOx emissions by 16% and 14%, respectively but increase NH_3 emissions by about 2%, particularly on acidic and slightly alkaline soils. These unintentional emissions may affect air quality, via formation of surface O_3 and PM2.5. While EW holds great potential for climate mitigation through CO_2 removal, the N_2O attenuation effect may be more critical to short term climate stabilization. However, a widespread implementation might have important consequences for crop and human health that are yet to be quantified.

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