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Methodologies for quantification of CO_2 drawdown by enhanced weathering

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Neutralisation of soil carbonic acid that arises from the equilibrium solubility-controlled dissolution of soil-gas CO_2 by downward percolating soil water, and its conversion to soluble dissolved bicarbonate, charge balanced by co-released metal cations (e.g. Ca^{2+}, Mg^{2+}) from weathering of soil minerals, constitutes a natural sink for atmospheric CO_2. Enhanced weathering for carbon dioxide removal (CDR) from the atmosphere for climate change mitigation exploits this geochemical process but aims to accelerate it by supplying freshly crushed materials such as olivine, basalt or more unusually, selected industrial mineral by-products as soil amendments. Addition of soil amendments seeks to accelerate CO_2 drawdown by increasing natural weathering rates to the point that measurable and economically viable rates of CO_2 drawdown from the atmosphere can be achieved within timescales of years to decades, ultimately resulting in increased land-to-ocean export of dissolved inorganic carbon (DIC), principally as bicarbonate ions. However, terrestrial enhanced weathering approaches for CDR face two important challenges. First, there is little consensus within either the scientific community or the nascent CDR industry about how weathering rates at amended sites should be optimized and second, clear methodologies for calculating gross CO_2 consumption per tonne of applied amendment, or per hectare of amended land surface have yet to emerge. The presentation will focus on results from a pilot field study, in which an industrial by-product, crushed returned concrete (CRC), was added to the upper 15 cms of a one-hectare trial site in SE Ireland at a rate of 10 tonnes/hectare. This material presents an advantage over traditional silicates (e.g. basalt) that have been investigated up to now to tackle the optimization and quantification problems alluded to above, because its weathering kinetics are relatively fast and clear geochemical signals associated with CO_2 drawdown emerge within timescales that are economically viable and logistically feasible for field monitoring. The results underline the need for a multi-proxy mass-balance approach that combines geochemical data from soil waters, time-series changes in bulk soil chemistry and soil-air gas fluxes to understand the rate-limiting factors at all stages in the process, from soil-gas dissolution to bicarbonate export.