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An investigation of crushed returned concrete (CRC) as a soil amendment for atmospheric CO_2 removal

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Soils have high pCO_2 because of the decay of organic matter and plant root respiration. Some of this CO_2 dissolves to form carbonic acid in soil waters. Natural weathering partially neutralizes this carbonic acid, but in recent years there has been much interest in using soil mineral and rock amendments (e.g. added olivine and basalt) to accelerate weathering-driven atmospheric CO_2 drawdown to counter rising atmospheric CO_2. To be effective, accelerated weathering should result in increased dissolved bicarbonate (the main dissolved inorganic carbon carrier at circum-neutral pH) in drainage waters, as well as enhanced land-to-ocean fluxes of divalent metal cations such as Ca and Mg, ultimately to lock up the soil-derived inorganic carbon in marine limestones. Here we present new results for field experiments that investigate a novel soil amendment to sequester CO_2 from soil-gas via weathering; crushed returned concrete (CRC). Unlike previously investigated mafic and ultramafic materials for accelerated weathering approaches that generally require energy- and carbon-intensive mining, grinding and long-distance transport operations, CRC is a waste product that requires minimal crushing after post-return solidification at concrete plants to achieve high measured specific surface areas (c. 10 m^2/g). CRC is widely available globally because a few % of the >10Gt/year of concrete produced is typically returned unused to concrete ready-mix plants. Engineering codes preclude the reincorporation of this waste as aggregate in new concrete in many jurisdictions. This results in the widescale availability of this highly weatherable alkaline waste product that is often landfilled or sold as a low-value construction fill. Local availability of the material facilitates short haulage distances and relatively small energy and carbon footprints to transport the material to nearby field sites. In this pilot study, CRC was added to the upper 15 cms of a one-hectare trial tillage field in SE Ireland at a rate of 10 tonnes/hectare. Soil-water solutions were extracted for analysis using suction-cup lysimeters at monthly intervals from the amended and adjacent non-amended control sites to determine the geochemical impact of CRC on soil waters and to calculate weathering and therefore CO_2 uptake rates via carbonic acid neutralisation. Relative to adjacent control sites, concrete-amended sites exhibited significant increases in soil-water pH (by 0.2 to 0.5 pH units), a two- to three-fold increase in electrical conductivity (total ion load) and similar increases in soil-water Ca^{2+}, reflecting the weathering of portlandite and calcium silicates in the concrete. Field experiments are ongoing to assess the long-term effects of the concrete amendment on soil-water chemistry, soil pH and nutrient status. No increases in detrimental heavy metals (e.g. Ni, Cr) often associated with the use of mafic and ultramafic materials as soil amendments have been detected. Weathering is attributable entirely

to carbonic acid neutralization, with no evidence for weathering by strong acids. Methods for the calculation of likely rates of CO_2 capture (tonnes CO_2 per tonne of amendment) and their associated uncertainties based on alkalinity increases, divalent metal exports and enhanced soil-leachable Ca will be discussed.