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Source or Sink? Evaluating CO_2 Fluxes From Urban Hardscape Surfaces

KILIAN ASHLEY, WILLIAM M BERELSON, DOUG LAROWE AND A. JOSHUA WEST

University of Southern California

Presenting Author: kashley@usc.edu

As of 2021, anthropogenic greenhouse gas (GHG) emissions have grown to at least 36.3 $Gt{\cdot}CO_2{\cdot}yr^{-1}$, two orders of magnitude more than any other major flux of the long-term carbon cycle. Nearly 7% (2.5 $Gt{\cdot}CO_2{\cdot}yr^{-1}$) of these emissions come from the production of cement, the binding agent that forms concrete. Cement production is unique amongst anthropogenic sources of GHGs in that the release of CO_2 during its production is partially offset by the uptake of CO_2 during the lifetime of the concrete. Previous work has shown that concrete can form carbonate minerals after long-term exposure to atmospheric CO_2, but these studies have focused on concrete samples taken at the end of their functional lifetime, typically greater than 50 years, and extrapolated the steady-state CO_2 uptake rates necessary to achieve the levels of carbonation observed over the course of the material's lifetime. Thus, there is little direct evidence of the actual carbonation rate of emplaced concrete or the short-term CO_2 fluxes that provide the reactive material needed. This study aimed to determine whether the rate of CO_2 uptake in concrete after emplacement matched the long-term estimates from previous studies. We accomplish this by directly measuring the CO_2 flux at the surface/atmosphere interface. Our results indicate that emplaced concrete can act as both a source and sink of atmospheric CO_2, and that these CO_2 fluxes vary depending on the specific environmental conditions present. Specifically, we find that emplaced concrete slowly absorbs CO_2 at a rate of 15.41 $mmol_{CO2}{\cdot}d^{-1}{\cdot}m^{-2}$ while it is dry, but upon wetting the concrete rapidly releases CO_2 into the atmosphere at a rate of 168.06 $mmol_{CO2}{\cdot}d^{-1}{\cdot}m\text{-}^{2}$. Due to its ubiquity as a building material, our findings suggest that emplaced concrete may not always act as a net sink of atmospheric CO_2 but may instead contribute a potentially significant fraction of global CO_2 emissions.