EGU2020-22447, updated on 02 Mar 2021
https://doi.org/10.5194/egusphere-egu2020-22447
EGU General Assembly 2020

Significance and driving forces of dark CO2 fixation for organic carbon inputs in temperate forest soils

Rachael Akinyede[1,2], Martin Taubert[1], Marion Schrumpf[2], Susan Trumbore[2], and Kirsten Küsel[1]
[1]Aquatic Geomicrobiology, Institute of Biodiversity, Friedrich Schiller University, Jena, Germany
[2]Department of Biogeochemical Processes, Max Planck Institute for Biogeochemistry, Jena, Germany

Soils are the largest terrestrial organic carbon pool and one of the largest terrestrial sources of CO_2 in the atmosphere. However, not all CO_2 produced in soils is released into the atmosphere, as dark CO_2 fixation has been shown to modulate CO_2 release from soils. Temperate forest soils store up to half of the soil organic carbon pool to 1m depth and are recognized as important components of the global carbon cycle, yet studies on dark CO_2 fixation in temperate forest soils are scarce. Using a well characterized Cambisol soil plot in the Hainich National Park (temperate forest), Germany, we explore dark CO_2 fixation with the aim to assess the CO_2 fixation rates, the influencing biogeochemical parameters, and the contribution of this process to temperate forest soil organic carbon (SOC).

Dark CO_2 fixation was quantified via the uptake of ^{13}C-CO_2 added to microcosms containing soils sampled from three depths. Under 2% CO_2 headspace, rates of dark CO_2 fixation at soil level decreased with depth from 0.86 µg C $gdw^{-1}d^{-1}$ in 0 - 12 cm to 0.05 µg C $gdw^{-1}d^{-1}$ in 70 -100 cm, accounting for up to 1.1% of microbial biomass and up to 0.035% of soil organic carbon. However, as differences in microbial biomass abundance and community profiles with depth were found, no significant difference in the rates across depth was observed at microbial level. This suggests that microbial biomass is an important driver of dark CO_2 fixation in soils. Given a global temperate forest area of 6.9 million km^2 and an average soil bulk density of 1 Mg/m^3 dark CO_2 fixation will potentially account for the gross sequestration of 0.31 - 0.48 GtC/yr to a depth of 1 m. Furthermore, an increase in headspace CO_2 concentration enhanced CO_2 fixation rates by up to 3.4-fold under 20% v:v CO_2 showing that dark CO_2 fixation can be substantial in soils with higher CO_2 concentrations.

To validate microbial biomass as a driver of dark CO_2 fixation in soils, we made comparisons with soil plots from the Schorfheide-Chorin exploratory forest, Germany, a temperate forest characterized by vegetation-specific bacterial community structure, higher sand content and acidic pH gradients. Under these conditions, CO_2 fixation rates at microbial level were significantly different across depth suggesting that aside microbial biomass, other abiotic factors may influence dark CO_2 fixation in these soils. Of all the tested abiotic variables, water content was the main explanatory factor for the variations in dark CO_2 fixation rates in the Schorfheide-chorin soils. Additionally, based on 16S rRNA sequencing, qPCR and PICRUSt2 analysis, only a few putative

autotrophic communities were present and displayed vegetation-specific variations indicating an influence of vegetation type and input on the active community.

Our findings highlight microbial biomass, CO_2 and water content as the main drivers of dark CO_2 fixation in temperate forest soils with only a small proportion of autotrophs being present, suggesting the potential mediators of this process. We also demonstrate the significance of this process in global temperate forest SOC inputs.