Geophysical Research Abstracts
Vol. 19, EGU2017-19606, 2017
EGU General Assembly 2017

Coupling of soil respiration and nutrient mineralization: What is the role of land use?

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Microbial decomposition of soil organic matter (SOM) is coupling carbon (C) and nutrient mineralization. In order to meet their stoichiometric requirements for growth, it can be assumed that microbes have to mineralize (or remove) relative more organic carbon (OC) to acquire limiting nutrients at sites with large carbon-to-nutrient (C:N, C:P, C:S) ratios of SOM. Land use and management intensities are important controls for belowground C and nutrient availabilities, but their effect on the combined carbon and nutrient mineralization and carbon use efficiency (CUE) have rarely been addressed. The main objective of this study was to test the effect of land use (forest versus grassland), forest management (unmanaged beech forest and age-class managed coniferous and deciduous forests) and grassland management (fertilized and unfertilized meadow, mown pasture and pasture) on the stoichiometry of mineralized C, N, P and S. We incubated a total of 120 topsoil samples (0-10 cm) from three German study regions with different soil types for two weeks in microlysimeters and measured CO_2 evolution and leachable organic carbon (DOC) and nutrients (NH4+, NO_3-, SO42- and PO43-). The relationships between metabolic quotient (microbial respiration per unit microbial biomass; qCO_2) and soil nutrient concentrations were compared between different land use and management. Preliminary results showed that qCO_2 was significantly higher ($p<0.001$) in forests than grasslands. This supports our hypothesis that under higher nutrient limitations in forest, more energy may be allocated for maintenance than growth. In forest, qCO_2 was strongly correlated to C:N ratio ($r =0.84$, $p<0.001$), while C:N was less strongly correlated with qCO_2 in the grasslands ($r =0.35$, $p>0.05$). As C:N ratio was significantly higher ($p<0.05$) in forests (14.9 ± 0.3) than grasslands (10.0 ± 0.3), this finding agreed with previous studies that more C per unit microbial C is respired under lower N availability. Similary in forests, qCO_2 was found to be strongly correlated to inorganic P (Olsen) content ($r =0.82$, $p<0.001$), whereas weaker correlation was observed in the grasslands ($r =0.47$, $p>0.05$). The stronger correlation in forests might indicate higher P limitation as compared to grasslands. Soil pH showed strong negative effect on qCO_2 in the forests ($r =-0.68$, $p<0.005$) while positively correlated to qCO_2 in the grasslands ($r =0.42$, $p<0.05$). This indicates that lower soil pH in forests results in higher qCO_2 and lower CUE, but higher soil pH in the grasslands could also constrain microbial activities and result in lower CUE. Our first results suggest that qCO_2 is affected by land use, and that this effect could be due to differences in nutrient availability. More analysis will follow to elucidate the interactions between qCO_2 and other nutrients, and how is this affected by forest and grassland management.