

Iron-mediated carbon dynamics in peatlands: the role of mineral crystallinity

YI-HO TSENG, ISABELLA OLGA ZELANO AND LAUREL THOMAS ARRIGO

University of Neuchâtel

Iron minerals play an important role in soil biogeochemistry. Ferric iron (Fe^{III}) minerals modify carbon dynamics by adsorbing organic carbon (OC) or occluding OC within microaggregates, yet also act as electron acceptors during heterotrophic respiration under anoxic conditions. In peatlands, a carbon-rich and waterlogged terrestrial ecosystem, the interaction between carbon and iron regulates the stabilization of OC or its transformation to greenhouse gases (CO_2 and CH_4). In addition to heterogeneous distribution across soils, the reactivity of iron minerals varies. Thus, the overall impact of iron on carbon dynamics remains unclear. To elucidate the role of Fe on OC dynamics, we designed anoxic soil incubations of ombrotrophic peat amended with varying Fe species:

reactive Fe (ferrihydrite, Fh; a ferrihydrite-silicate coprecipitate, FhSi; a Fe^{III} -peat complex, FePeat) and crystalline Fe (goethite, Gt) either in pure forms (Fh, FhSi, and Gt) or mixtures of the two (95/5% Gt/Fh, GtFh; 95/5% Gt/FePeat, GtFePeat). The anoxic incubations lasted for 70 days. Two incubation series were prepared for measuring (1) the headspace CO_2 concentrations (over 60 days) and (2) pH, Eh, and OC and Fe speciation in both the aqueous- and solid-phase.

The results show that Fe additions changed the carbon dynamics. The reactive species (i.e., Fh, FhSi) promoted CO_2 production and resulted in higher concentrations of aqueous Fe, suggesting reductive dissolution of the minerals, as they served as extra electron acceptors for microbial respiration. In contrast, the goethite addition alone did not affect CO_2 production until the 20th day of anoxic incubation, after which CO_2 production was first inhibited and then promoted (after 42 days) compared to a control treatment without Fe additions. However, when small fractions (5%) of reactive Fe species were added alongside goethite (GtFh and GtFePeat), CO_2 production was up to 2.2 times higher than in the pure Gt treatment. The lowest DOC concentrations were measured in Fh and FhSi, suggesting that the ferrihydrites re-adsorbed the OC present in the soil-solution.

These results illustrate the complex impacts of Fe species on carbon dynamics and highlight the vulnerability of peatlands as carbon sinks in the context of environmental changes.