Effects of biochar management on litter-soil-atmosphere greenhouse gas (GHG) exchange in a warming environment

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Forest has an enormous potential in affecting climate change through soil-atmosphere exchange of greenhouse gases (GHGs). Biochar management is considered to be a promising approach to combat anthropogenic climate change and improve soil fertility, but its impacts on forest soils remain largely unclear. Two laboratory incubation experiments were conducted in China and Austria using subtropical and temperate forest soils, respectively, to investigate the effects of short-term (one month, China) and long-term (~four years, Austria) biochar management on litter-soil-atmosphere GHG fluxes under a warming environment.

Warming significantly stimulated soil CO\textsubscript{2} and N\textsubscript{2}O emission, but significantly suppressed CH\textsubscript{4} uptake. The priming effects of leaf litter on soil CO\textsubscript{2} emissions were greater with the deciduous litter in China than the coniferous litter in Austria. Although biochar did not have any significant effect on soil CO\textsubscript{2} fluxes, its application significantly decreased CH\textsubscript{4} uptakes up to 101 %. Moreover, N\textsubscript{2}O emissions from temperate forest soils were significantly reduced by 84-95 % after biochar addition, but N\textsubscript{2}O emissions from subtropical soil showed insignificant response to biochar addition. In the short-term biochar application in China, soil available P and NH\textsubscript{4}\textsuperscript{+} were enhanced, while soil NO\textsubscript{3}\textsuperscript{−}, microbial biomass carbon and microbial biomass nitrogen were reduced. In contrast, the long-term biochar application in Austria only enhanced soil available P.

Our results suggest that warming would trigger positive responses of soil GHG emissions, and thereby contributing to global warming. Biochar management could serve as an effective approach to sequester stable carbon and improve soil nutrient, but cautions should be taken when utilizing biochar to mitigate climate change as its impacts on soil GHG exchange could vary under different environmental conditions.