Understading Biochar Nitrate Capture to Tailor Nitrogen Cycling in Agroecosystems

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Biochar, i.e. charcoal produced by pyrolysis of biomass for applications in agriculture, is suggested as a beneficial soil amendment to increase crop yields and to tailor biogeochemical cycles in agro-ecosystems to reduce both greenhouse gas emissions and nutrient leaching. Prior to soil amendment, biochar must be "loaded" with nutrients to avoid an initial plant growth reduction by e.g. nitrogen immobilization. Co-composting is suggested as a superior method, as co-composted biochar promoted plant growth and showed a desired slow release of nutrients like nitrate ("nitrate capture", Kammann et al., 2015 SR5:11080). The slow release of nitrate was recently shown for earth-aged biochar, too (Haider et al., subm.), however underlying mechanisms are still not understood and nitrate capture has just been quantified for isolated biochars.

For the first time, we quantified nitrate capture with repeated extractions not only for biochars, but also for biochar amended soil and compost. Additionally, we confirmed nitrate capture for pristine biochar after soaking in NH_4NO_3 solution in the absence of any additional organic carbon, too. However, assuming pseudo-first order kinetics for biochar nitrate release, we found differences in the affinity of pristine, co-composted and earth-aged biochars to nitrate. Spectro-microscopical investigations (STEM-EELS, STXM) revealed the formation of a nano-porous organic coating on co-composted biochar that might explain its distinct characteristics. These findings offer a roadmap for future research to design sustainable slow release nitrogen fertilizers based on biochar to reduce the environmental impact of agriculture by tailoring the biogeochemical fate of nitrogen in agroecosystems.