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Influence of 13 different biochars on N_2O production and its sources during rewetting-drying cycles

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Biochars have been found to have variable impacts on nitrous oxide (N_2O) emissions. The variability has been attributed to differences in soil – biochar properties and microbial communities. While some information exists on biochar and soil properties, the effect of biochars on microbial sources of N_2O is still a matter of speculation. In this study, we tested these effects for12 biochars prepared from cypress, loblolly pine and grape wood produced at four different controlled temperatures (350, 500, 700 and 900˚C), respectively, plus a grapevine Kontiki biochar (600-700˚C).

The biochars were added (2%) to a loamy sand brought to pH 7.1 with CaO. The treatments plus one control were pre-incubated at 40% water holding capacity (WHC) for four days. Then, they were brought to 80% WHC and ^{15}N-nitrate was added (50 mg NO_3^--N kg^{-1} soil, 10% enriched in ^{15}N). All treatments were set up with four replicates. In total, three cycles of (re)wetting – drying (80 to 40% WHC, total duration 20 days) were monitored. Samples for analyses of N_2O concentrations and stable isotope signatures were taken daily (except for weekends) after closing the incubation vessels for 90 minutes.

N_2O emissions increased with each addition of water and decreased during drying to background values. Each rewetting led to larger emissions than measured in the previous cycle for all treatments including controls. All biochars decreased total N_2O emissions compared to the control treatments. The higher the production temperature of the biochar, the larger usually the emission reduction. Largest effects were found for the grape wood and the Kontiki biochars. Interestingly, the addition of biochars also changed the isotopic signatures of the emitted N_2O. Whereas emissions in the controls were enriched to about 5 atom% ^{15}N excess at peak emissions, the enrichment was usually less after addition of biochars (1-5 atom% excess). Again, this effect tended to be larger at higher production temperatures of the biochars and was greatest for the grape wood and Kontiki biochars.

The results indicate that NO_3^- was an important source for N_2O emissions under the conditions of the study, probably by denitrification. The addition of biochars changed not only the amount of emissions, but also the N source of emissions. In this study, N_2O production from labelled NO_3^- was a smaller source of emissions after addition of biochars (especially produced at high temperatures) than in control treatments. This indicates that the ^{15}N-NO_3^- source was diluted by (accelerated) mineralization-nitrification or that microbial sources using other substrates but added NO_3^- contributed more to N_2O production. Whether potential capture of NO_3^- by biochars could contribute to this, needs to be further investigated.

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