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Identification and quantification of nitrogen cycling processes in cryptogamic covers

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Cryptogamic covers (CC) comprise communities of photoautotrophic cyanobacteria, lichens, algae, and bryophytes together with heterotrophic bacteria, microfungi, and archaea in varying proportions. Depending on their habitat, cryptogamic rock covers, cryptogamic plant covers, and cryptogamic soil covers are distinguished. The latter comprise biological soil crusts (biocrusts), which globally occur under dryland conditions. In a first assessment of their global role, we quantified that CC fix ~49 Tg of nitrogen (N) per year (Elbert et al., 2013), corresponding to ~1/2 of the maximum terrestrial biological N fixation determined in the latest IPCC report. The fixed N is used for biomass formation and partially leached into the ground, where it can be taken up by plants or transformed into N oxides, being emitted into the atmosphere.

We show that biocrusts release nitric oxide (NO) and nitrous acid (HONO), which are key species in the global cycling of nitrogen and in the production of ozone and hydroxyl radicals, regulating the oxidizing power and self-cleaning capacity of the atmosphere. Based on laboratory, field and satellite measurement data, we obtained a best estimate of 1.1 Tg a^{-1} of NO-N and 0.6 Tg a^{-1} of HONO-N being globally emitted by biocrusts, corresponding to ~20% of the global nitrogen oxide emissions from soils under natural vegetation (Weber et al., 2015). During full wetting and drying cycles, emissions peaked at low water contents suggesting NO- and HONO-formation under aerobic conditions during nitrification. Other measurements revealed that cryptogamic organisms release nitrous oxide (N_2O), a greenhouse gas of crucial importance for climate change. The emission rates varied with temperature, humidity, and N deposition, but divided by respiratory CO_2 emission they formed an almost constant ratio, which allowed upscaling on the global scale. We estimated annual N_2O emissions of 0.3 – 0.6 Tg by cryptogams, accounting for 4-9% of the global N_2O budget from natural terrestrial sources (Lenhart et al., 2015). ^{15}N isotope labeling experiments revealed that nitrate (NO_3^-) was a precursor of N_2O, suggesting that N_2O may be formed during denitrification. Thus, our experiments revealed that CC play a prominent role in different steps of the N cycle, being relevant in terrestrial biogeochemistry, atmospheric chemistry and air quality.

Literature

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