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Effect of fire in Mediterranean shrub-land on soil nitrogen cycling and emissions of nitrous oxide

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Extended drought periods as predicted for future climatic conditions will possibly increase the frequency of fires in the Mediterranean region. Due to fires, the availability of both mineral and organic nitrogen (N) forms in the top soil may increase. This possesses the risk for post-fire peak emissions of gaseous nitrogen. We investigated soil N mineralization-immobilization turnover (MIT) and nitrous oxide (N_2O) emissions during a 204 days post-fire period in a central Spain Mediterranean shrub-land. Burning effectively increased the potential for N_2O production in incubated soils where N_2O (burned) emissions were 4 to 40 times higher than N_2O (control). N_2O was produced solely from the soil nitrate (NO_3-), emphasizing denitrification as the pathway. We conclude that fire markedly increases the risk of N_2O emissions in Mediterranean shrub-land. Potential N_2O emissions and soil N turnover were studied with laboratory incubations and 15N labelling of soils sampled 1 day before and 3, 13, 35 and 204 days after burning of the shrub-land (3 control plots, 3 burned plots). Soils were labelled with ammonium nitrate (NH_4NO_3) and incubated in glass jars for 48 h (soils received either double labelled $^{15}NH_4{}^{15}NO_3$ or single labelled $^{15}NH_4NO_3$, 5 atom% excess, 10 μg N/g moist soil). Gas samples were taken at 0, 12, 24 and 48 h for analysis of headspace N_2O-concentrations to calculate N_2O production rates with the linear regression method. A larger gas sample was collected at 48 h for analysing 15N enrichment of the produced N_2O. Soils were extracted with 0,01 M $CaCl_2$ immediately and 48 h after labelling, and concentrations and ^{15}N enrichments of extractable ammonium (NH_4) and NO_3- were measured. Contribution of NH NH_4 and NO_3- pools to N_2O production could then be calculated with the two-pool mixing model, using average enrichments of the NH NH_4 and NO_3- pools during the incubation. Gross N turnover rates were calculated based on the ^{15}N-isotope pool dilution method. Burning consistently increased potential N_2O production from soil (Fig.1). Soil NO_3- pool was the sole source of produced N_2O, indicating that N_2O was mainly produced from denitrification. The increased N_2O production could not be verified from field observations at the same site (unpublished), suggesting that soil structural characteristics are important for in situ N_2O reduction to occur. The increase in N_2O production was not related to changes in gross N cycling after fire. Gross N mineralisation averaged 0.29 μg N g^{-1} soil d.w. $h-1$ independent of fire treatment, and also N immobilization rates (average 0.27 to 0.28 μg N g^{-1} soil d.w. h^{-1}) were similar between the burned and control soils. However, the NO_3- accumulation observed in unburned soil was not apparent in burned soil 3,13 and 35 days after burning, supporting the proposed increase in denitrification. The current study contrasts finding by Dannenmann et al. (2011) who observed increased gross N mineralization and unaltered N_2O production after fire in Italian Macchia. Fire interactions with soil N cycling and GHG emissions thus seems to be very site specific, asking for further investigations.