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Environmental properties and microbial abundance explain soil nitrous oxide flux variation synergistically under the addition of nitrogen and water in temperate semi-arid steppe

Zhang Jiaqi and Liu Yinghui
Institute of Geographical Science, Beijing Normal University, Beijing, China (zofbfu@163.com, lyh@bnu.edu.cn)

With the increasing of nitrogen(N) deposition and changing of precipitation patterns worldwide, large amounts of N are loaded in terrestrial ecosystem, resulting in soil nutrient imbalance and soil nitrous oxide(N_2O) flux change. Nitrification and denitrification in soil are two major sources of N_2O emission mediated by microorganisms. However, It is still unclear how the soil N_2O flux and the abundance of nitrifiers and denitrifiers might change under the addition of N and water(W) in temperate semi-arid steppe. In this study, we established a one-year-long field experiment investigating how soil N_2O flux, the abundance of nitrifiers and denitrifiers, and environmental properties, including soil pH, soil moisture, soil dissolved organic carbon content(DOC) and soil available N content responsed when N(NH_4NO_3 was applied at a rate of 4 g $N{\cdot}m^{-2}{\cdot}yr^{-1}$, which is equivalent to one time the annual nitrogen deposition) and/or W(water was applied at a rate of 112.5 $mm{\cdot}yr^{-1}$, which is equivalent to 30% of the annual rainfall) were added to temperate semi-arid steppe in northern China with the natural condition without any treatment as control. Quantitative PCR was used to analyze the abundance of ammonia oxidizers(ammonia-oxidizing bacteria and archaea amoA) and denitrifiers(nirS/nirK and nosZ). Our experimental results demonstrated that soil N_2O emission decreased when W was added and W and N were added in temperate semi-arid steppe in northern China. The abundance of nirS and nosZ genes increased when W and N were added. Compared with AOA/AOBamoA and nirK genes, the abundance of nirS and nosZ genes is more sensitive to the addition of N and W. Soil N_2O flux was negatively correlated with the abundance of nirS-denitrifier. The nirS gene abundance, soil pH and DOC were the main controls on soil N_2O flux and totally explained 78.2% of the variation of soil N_2O flux. The results of this study provide a theoretical basis for N cycle mechanism mediated by microorganisms and have practical significance for the prediction of N_2O flux change in temperate semi-arid steppe under the background of global change.