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Isotopomer analysis of nitrous oxide produced in a seasonally frozen soil

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Nitrous oxide (N_2O) is a potent green house gas of which radiative forcing is about 200 times larger than that of CO_2 and contributes to ozone depletion in the stratosphere. In seasonally frozen soil, it is known that more than 50% of the annual N_2O emission occurs during spring snowmelt period. In order to investigate the N_2O production/consumption mechanism under the soil thawing events, we performed isotopomer analysis of N_2O at an experimental agriculture field plot in northern Japan. It is suggested that intramolecular ^{15}N site preference (SP) of N_2O, that is defined as difference in isotope ratios between central (N^a) and terminal (N^b) nitrogen in the N_2O (NNO) molecule, is a powerful tool to quantitatively analyze the contribution of important production pathways such as nitrification, fungal denitrification, chemo-denitrification and bacterial denitrification together with the presence of N_2O reduction, in addition to the isotope ratio of N ($d^{15}N$) and O ($d^{18}O$).

The diffusion chamber method using silicone tube, which is recently applied to gas sampling from each soil depth, is useful method for revealing biological processes in soils. In order to apply this method to isotopomer analysis, diffusion equilibrium of N_2O (concentration, $d^{15}N$, $d^{18}O$, SP) was confirmed by laboratory experiment. As a result, no significant difference in concentration and isotope ratios between outside and inside of the silicone tube was detected, suggesting the diffusion method can be applied to in situ soil gas sampling for N_2O studies.

We, then, investigated the isotopomer signatures of soil N_2O collected from the seasonally frozen soil under soil thawing events. Isotopomer ratios showed no significant variation during N_2O production peak in subsoil. Both SP and $d^{15}N$ of N_2O were within the range of the reported values for bacterial denitrification, suggesting that N_2O produced during spring snowmelt period was derived from bacterial denitrification and the contribution of N_2O reduction was likely to be very low.

Keywords: Nitrous oxide, Isotopomer, Frozen soil, Denitrification