Temperature Sensitivity of N$_2$O and N$_2$ Emissions from Ten Forest Soils

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Temperature sensitivity ($Q_{10}$) of soil N$_2$O and N$_2$ emissions from terrestrial ecosystems and its controlling factors are essential for predicting the effects of global warming on nitrogen (N) cycle. Although the warming-induced effects on soil N cycle is considered to be positive in general, our understanding of how N$_2$O and N$_2$ emissions respond to climate change is rather limited. To quantify the $Q_{10}$ of N$_2$O and N$_2$ emissions in forest soils and to identify their major driving factors, we performed an incubation experiment using $^{15}$N tracer (Na$^{15}$NO$_3$) with soil samples from ten forest sites with a large geographic distribution and a wide range of climate conditions. The sites stretched from temperate to tropical zones, with mean annual temperature (MAT) ranging from 3 to 21.5°C and mean annual precipitation (MAP) ranging from 300 to 2449 mm. The soil pH varied between 3.57 to 6.27.

The samples were incubated for 12 or 24 hours under anaerobic condition at temperature from 5 to 35°C with an interval of 5°C, respectively. Soil temperature strongly affected the production of N$_2$O and N$_2$; N$_2$O and N$_2$ production rates showed a positive exponential relation with incubate time and temperature for all forest soils. Our results showed that the $Q_{10}$ values ranged from 1.31 to 2.98 for N$_2$O emission and 1.69 to 3.83 for N$_2$ emission, indicating a generally positive feedback of N$_2$O and N$_2$ production to warming. Higher $Q_{10}$ values for N$_2$ than N$_2$O implies that N$_2$ emission is more sensitive to temperature increase. The N$_2$O/(N$_2$O+N$_2$) decreased with increasing temperature in seven of ten forest soils, suggesting that warming accelerates N$_2$ emission. Strong spatial variation in $Q_{10}$ were also observed, with tropical forest soils exhibiting high $Q_{10}$ values and relatively low $Q_{10}$ in temperate forest soils. This variation is likely attributed to the inherent differences in N biogeochemical cycling behavior between the microbial communities among sites. Despite soil temperature primarily controls the N$_2$O and N$_2$ emissions, we will further explore the effects of other factors such as pH and C/N, and perform additional experiments to elucidate the role of other factors on $Q_{10}$. In addition, we will partition N$_2$O and N$_2$ emissions to different microbial processes (e.g., denitrification, co-denitrification and anammox) and examine the temperature sensitivity of those different microbial processes, on the basis of the $^{15}$N isotope pairing technique.

Key words: Temperature sensitivity, N$_2$O, N$_2$, Forest soil, Nitrogen cycle, Global warming