18. Effects of soil freeze-thaw cycles on microbial biomass and organic matter decomposition, nitrification and denitrification potential of soils

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Abstract

Melting of the permafrost is one of the biggest concerns corresponding to the progress of global warming. In addition, change in soil freeze-thaw patterns in boreal and temperate regions can also arise. The phenomenon of soil freeze-thaw cycles is known to affect some nutrient cycling and greenhouse gas flux associated with microbial activities in the soil, especially excessive N_2O burst. Therefore, oncoming disappearing of the night-day successive freeze-thaw cycles at the surface layer in temperate regions and oncoming increasing in the frequency of the freeze-thaw cycles in boreal regions or permafrost at the surface layer can cause serious problems in both regional nutrient dynamics in the soil and the global-wide greenhouse gas fluxes from soil. However, there was little information about what kinds of stresses are exposed to the soil microbial communities by the soil freeze-thaw cycles, and then, how their metabolic activities could be changed. In the present study, therefore, effects of soil freeze-thaw cycles on soil microbial communities were investigated using soil samples collected from tropical regions (where there are no soil freeze-thaw cycles) and temperate regions (where the freeze-thaw cycles in the surface soil layer can disappear in the future). The results were analyzed to account for excessive N_2O burst associated with the soil freeze-thaw event. The amounts of soil microbial biomass C and N decreased significantly by 6 to 40% following four successive soil freeze-thaw cycles (-13 and +4℃ at 12 h-intervals) compared with the unfrozen control (kept at 4℃ during the same period of time as that of the freeze-thaw cycles), suggesting that a part of the microbes were lethally affected and then their cell components were released into soil. Despite decreasing microbial biomass, organic matter decomposition potential was not inhibited by the soil freeze-thaw cycles depending on the substrate amended. On the other hand, nitrification potential was inhibited by the freeze-thaw cycles depending on the soil pH level. These results indicate that the soil freeze-thaw cycles might affect nutrient condition for denitrification (C source and NO_3^-). Denitrification potential (C_2H_2-inhibition based N_2O production) was detected all of the samples examined, although nitrification potential was not detected in the 3 out of 8 soil samples, and was not inhibited by the freeze-thaw cycles. On the other hand, a higher ratio of N_2O in total denitrification products (N_2O/N_2+N_2O value) was observed in the soil sample subjected to the freeze-thaw cycles, suggesting that N_2O reducing activity could be inhibited. Thus, in tentative conclusion, soil freeze-thaw cycles might result in excessive N_2O burst due to making condition preferable for denitrification and inhibition of N_2O reducing activity.