Succession of soil nitrification potential at a glacier foreland in Svalbard

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Glaciers in Svalbard particularly in the western part of the archipelago has experienced retreating since 20th century. It is concerned that the retreat has been accelerated recently. Glacier retreat on the land uncovers the ground surface under ice. This is a restart of soil genesis as the past soil was lost due to ice erosion. What does happen in nitrogen cycle of the redeveloping soil, and how does ongoing climate warming affect the redeveloping soil nitrogen cycle? In the present study, we focus on nitrification as a source of nitrate. Nitrification is a two-step microbial process consisting of ammonia oxidation to nitrite and nitrite oxidation to nitrate, in which ammonia oxidation is the rate limiting step. Nitrifiers are basically autotrophic and therefore contribute to soil nitrogen cycle from the early stage of soil genesis. It is also interesting that nitrifiers exist across the two domains, bacteria and archaea. The purposes of the present study are to investigate nitrification properties (ammonia oxidation potential [AOP] and flora of nitrifiers) and their time-series changes in the surface soil in the foreland of East Brøgger Glacier near Ny-Ålesund, Svalbard and to elucidate responses of the nitrification properties to environmental manipulations (passive warming and accompanied changes in soil moisture) using open top chambers (OTC). We have been conducting a field experiment at two permanent exclosures established by NIPR in the foreland, i.e., Site 1 (N78°54'46", E11°50'18") and Site 2 (N78°54'54", E11°49'38"). It is inferred from aerial photos that Site 1 lost its ice coverage between 1969 and 1977, and Site 2 in 1950s or 1960s. Although the foreland was abundant with rocks and stones, the surface was partly covered with mineral soil consisting of fine sand and silt. The field experiment started in July 2015. A passive warming plot and a control plot were set at each site. Twenty polyvinylchloride cores filled with 4-mm sieved and well mixed surface soil collected at each site were set at each of the warming and control plots, of which 5 cores were used to measure soil temperature and volumetric water content and the rest 15 cores were for determining nitrification properties of topsoil (0-2 cm) and subsoil (2-4 cm) collecting 3 cores every July. The field experiment will be end in the summer of 2020. AOP was determined as the nitrite production rate of soil by aerobic shaking incubation with substrate (ammonium sulfate) at 10 and 20 °C. Nitrifiers' flora, i.e., gene abundance and species composition of ammonia oxidizing bacteria and archaea will be identified after the completion of field experiment. Annual mean warming effects of the OTC were 0.4–0.5 °C at Site 1 and 0.5–0.7 °C at Site 2; however, stronger warming effect appeared in the snow season. OTC effects to soil moisture were moistening at the warming plots for the first year, but it turned into drying after that. The determined AOPs at Site 2 were roughly double of those at Site 1. Differences in AOP between the warming and control plots and between the topsoil and subsoil were not significant. The time-series changes in AOP were not monotonous. Meanwhile, AOPs at 20 °C were significantly larger than those at 10 °C for sites, topsoil and subsoil, and time-series changes. Annual mean soil temperatures at the two sites were from −1.5 to 0.3 °C, from 5 to 6 °C in the snowless season, and 14 °C as the maximum daily mean. The positive response of AOP to a high temperature of 20 °C implies that future climate warming accelerates soil nitrification in the foreland. Although it is early to conclude, the succession of AOP at 10 °C was unclear and that at 20 °C showed an increasing trend. This study was supported by Grants-in-Aid for Scientific Research (No. 26304018) provided by the Japan Society for the Promotion of Science. This study was also partly supported by the National Institute of Polar Research, Japan, through Project

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