アラスカ寒帯森林土壌及びツンドラにおける二酸化炭素・メタンフラックスと土壌微生物群集によるセルロース分解活性

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CO_2, CH_4 fluxes and microbial cellulose degradation activities in terrestrial ecosystem of boreal forest and tundra, Alaska

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Arctic and sub-arctic terrestrial regions store large amounts of organic carbon in soil. This carbon stock assumes a large role because global warming is expected to be greatest at high latitudes and induce acceleration of biological decomposition. Soil respiration is a major flux in the global carbon cycle. Response of terrestrial CO_2 and CH_4 fluxes to global warming is sensitive to slight changes in the soil temperature, water table level, and microbial activity. Therefore, it is important to know the dynamics of soil CO_2 and CH_4 fluxes and microbial activity in these regions. This will be essential to predict how Arctic terrestrial ecosystems respond to climate change.

We measured soil CO_2 and CH_4 fluxes using closed chamber methods with vacuumed vials in 4 different sites along the trans-Alaska pipeline in summer season of 2010, 2011, and 2012. These sites were located in boreal forest and tundra regions. The concentrations of CO_2 and CH_4 in the vials were quantified by TCD & FID-GC (Shimadzu, GC-14A) at the laboratory in Japan. Soil CO_2 fluxes also measured at the same sites using portable soil respiration measurement system (PP systems, EGM- 4). Soil temperature (depths of 5 and 10 cm), soil organic carbon contents, water content, and soil bulk density were also determined. To evaluate soil microbial activities in the region, we performed cotton strip assay as measurement method of microbial activity. Cotton fabrics were buried into soil in 2011 and then recovered as samples after 1 year incubation. These cotton fabric samples were cut with depth, and these tension strengths were measured using tension-compression test instrument (Orientec, STA-1225). Weakness of the tension strength represents cellulose degradation by microbes, which indexes of microbial activity. We also collected soil sample for bacterial diversity analysis. Bacterial diversities for each site were analyzed by terminal restriction fragment length polymorphism analysis (T-RFLP) and 16S rDNA partial sequences.

Average soil CO_2 fluxes measured by the portable system were 0.07 and 0.16 (Sub-alpine tundra), 0.37 and 0.42 (Boreal white spruce forest) g CO_2 m^{-2} h^{-1} in 2010 and 2011 respectively. These CO_2 fluxes tend to be related with soil temperature of 5 cm depth. Soil CH_4 fluxes showed minus (-0.004 mg CH_4 m^{-2} h^{-1}) at Boreal white spruce forest site and ranged from 0.027 to 0.22 mg CH_4 m^{-2} h^{-1} at tundra sites in 2011. These results agree with previous researches which reported boreal forest soil was large atmospheric methane sink (Burke et al., 1997). Microbial activity measured by cotton strip assay showed that cellulose degradation activity was different for site and depth. At surface layer in Boreal white spruce forest sites had high degradation activity (the tention strength of imcubated sample became 10% of control), but such a high activity was not observed in sub-alpine tundra and tundra sites. This method would be suitable for measuring of annual microbial activity in Alaska where access is not easy and climate is drastically changed in summer and winter season. For details about relationship between soil gas fluxes and the environmental factors, microbial community structure at each site will be presented in the conference.

Reference

Burke, R. A. et al. Effect of fire on soil-atmosphere exchange of methane and carbon dioxide in Canadian boreal forest sites, Journal of Geophysical Research: Atmospheres, 102(D24), 29,289-29300, 1997.