Methane Flux and Oxidation in a Thermokarst Bog in Interior Alaska: The Role of Plants

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Methane is a potent greenhouse gas, and wetlands represent the largest natural source of methane to the atmosphere. A majority of the emitted methane travels through hollow aerenchyma tissues inside emergent plants, which also support the diffusion of atmospheric oxygen down to the rhizosphere. Previous studies have shown that oxidation of methane by oxygen released into the rhizosphere by plants is capable of converting ~90% of CH4 produced within wetlands to CO2. Most current large-scale wetland models represent rhizospheric methane oxidation as a constant percentage (i.e., 40–50%) of the methane transported by plants. Oxidation is an important methane sink and changes in the rate of methane oxidation can affect wetland methane emissions. In a thermokarst bog located in Interior Alaska, we conducted a series of measurements and experiments to clarify the impact that plants in this system have on rates of methane oxidation. On individual *carex* plants isolated in a plant-flux chamber, we measured rates of both plant-mediated methane emission and methane oxidation; we assessed methane oxidation by measuring methane flux after removing oxygen from the flux chamber. After accounting for *carex* density at the plot scale, we estimated that ~40% of emitted methane traveled through plants. However, we detected minimal to no methane oxidation along the plant-transport pathway. In conjunction with the plant-level flux measurements, we conducted a plant manipulation experiment where we tracked rates of methane emission and methane oxidation on treatments with natural vegetation, with vascular plants removed, and with vascular plants removed and "replaced" with gas permeable tubing. We found that the treatment with the natural vegetation had increased rates of methane emission and, surprisingly, decreased rates of methane oxidation relative to the two other treatments. We hypothesize that plant carbon inputs not only fuel methane production but also provide substrate for heterotrophic microbial communities that compete with methanotrophs for oxygen, thus diminishing the availability of oxygen for methane oxidation. This hypothesis is supported by data collected from *in situ* oxygen injection experiments conducted against optical oxygen sensors installed in the bog against both naturally vegetated peat and peat with vascular plants removed. Over the season, in the shallow depths (~15 cm) oxygen consumption rates were generally faster in the presence of plants. Collectively, these data indicate that in the studied thermokarst bog, no only is minimal to no methane oxidation occurring in the rhizosphere of plants, but plants are decreasing rates of methane oxidation.