Landfill cover soils: variable moisture and temperature effects on methane oxidation

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Landfills are one of the largest anthropogenic sources of methane (CH4), comprising over 20% of Canada's CH4 emissions. Hot-spots of CH4 emissions in landfill cover soils have shown an enrichment of microbes that consume CH4 and produce carbon dioxide (CO2) through CH4 oxidation, which can act as a natural solution to reduce CH4 emissions. CH4 oxidation is affected by soil moisture and temperature, although their simultaneous effects on CH4 oxidation rates have not been well-studied. Here, we conducted a closed-headspace batch experiment with cover soil from a former landfill in Waterloo, Ontario, to measure CH4 oxidation and CO2 efflux rates associated with variations in soil moisture and temperature simultaneously. The soil samples were prepared under 5 soil moisture contents (% WFPS; water-filled pore space), ranging from 11 to 47% WFPS, and incubated following a regime whereby temperatures increased from 1 to 35°C (Phase I) then decreased from 35 to 1°C (Phase II). Every 2 days, the temperature was adjusted to the next value for a 24-hour acclimation period while open to the atmosphere, then the headspace was closed and spiked with CH4 (150 ppm). Headspace CH4 and CO2 concentrations were measured over 2 hours to calculate apparent CH4 oxidation and CO2 efflux rates. The maximum CO2 efflux rate was observed at the maximal WFPS and temperature conditions of this experiment (91.5 nmol h-1 g dry wt.-1 at 47% WFPS and 35°C). In contrast, the maximum CH4 oxidation rates were observed at intermediate WFPS and temperature conditions (1.86 nmol h-1 g dry wt.-1 at 25% WFPS and 25°C). These experimental results provide insight into favourable WFPS and temperature conditions for CH4 oxidation, and therefore into how seasonal changes in WFPS and temperature could impact CH4 oxidation.