Methane oxidation in landfill cover soils under variable moisture and temperature conditions

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Background

- Landfills make up ~25% methane (CH_4) emissions in Canada
- Priority target for mitigation: "hot-spots" of unmonitored CH_4 emissions in landfills
- Hot-spots have shown an enrichment of CH_4-oxidizing microbes that consume CH_4 and produce CO_2 → natural control for CH_4 emissions
- Simultaneous effects of soil temperature and moisture on CH_4 oxidation have not been well studied

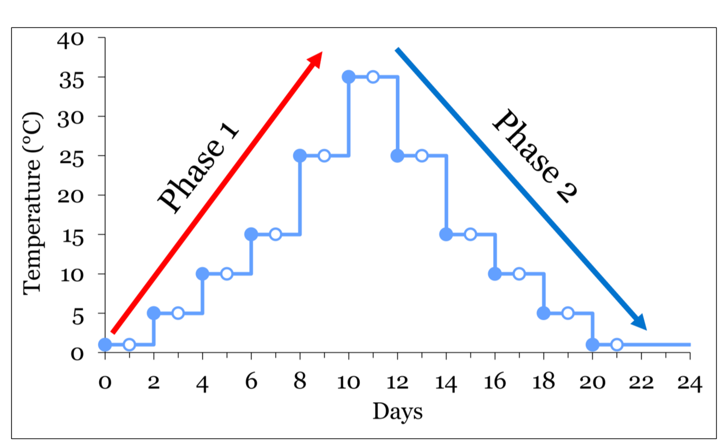
Objective: Assess CH_4 oxidation activity under conditions simulating seasonal variations in **both** moisture and temperature regimes

Hypothesis: Variations in soil temperature & moisture will affect capacity for **CH_4 oxidation**

Materials and Methods

- Landfill cover soil was collected from a former landfill (McLennan Park) in Kitchener, Ontario
- A closed-headspace batch experiment was conducted to measure CH_4 oxidation and CO_2 efflux rates:
  - ➢ 5 soil moistures, ranging from 11-47% WFPS (water-filled pore space)
  - ➢ Temperature increased from 1 to 35°C (Phase I) and decreased from 35 to 1°C (Phase II)

Gas sampling from the jars

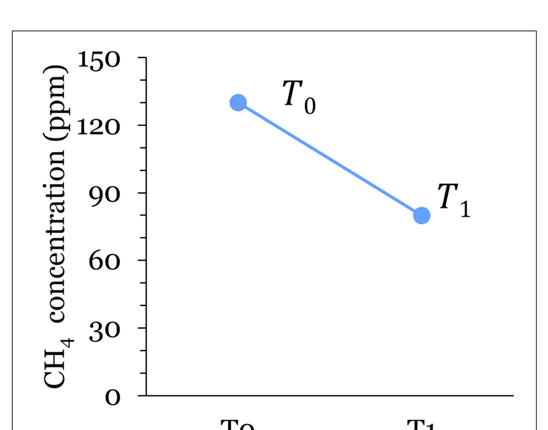


Temperature regime

- 2-day sampling:
  1. Jars are open to atmosphere for 24-hr acclimation to new temperature
  2. Headspace is closed
     → spike with CH_4 (150 ppm)
     → gas samples are taken over 2 hrs (headspace CH_4 and CO_2 concentrations using Gas chromatography)

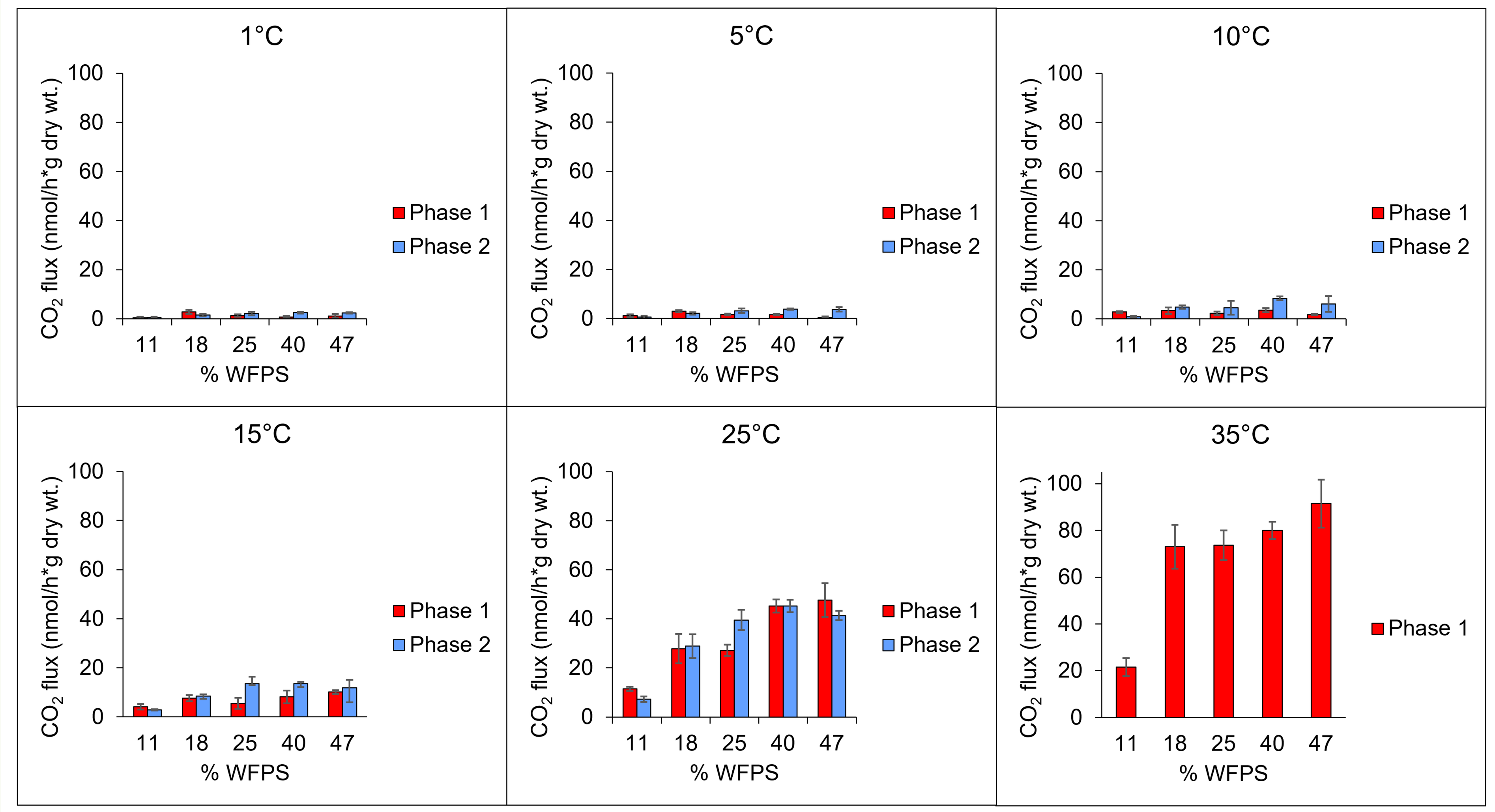
- CH_4 oxidation and CO_2 efflux rates are calculated using the difference in concentration over 2 hrs

$$F_{gas} = \frac{\Delta C_{gas} V}{RT \Delta t V_{soil}}$$



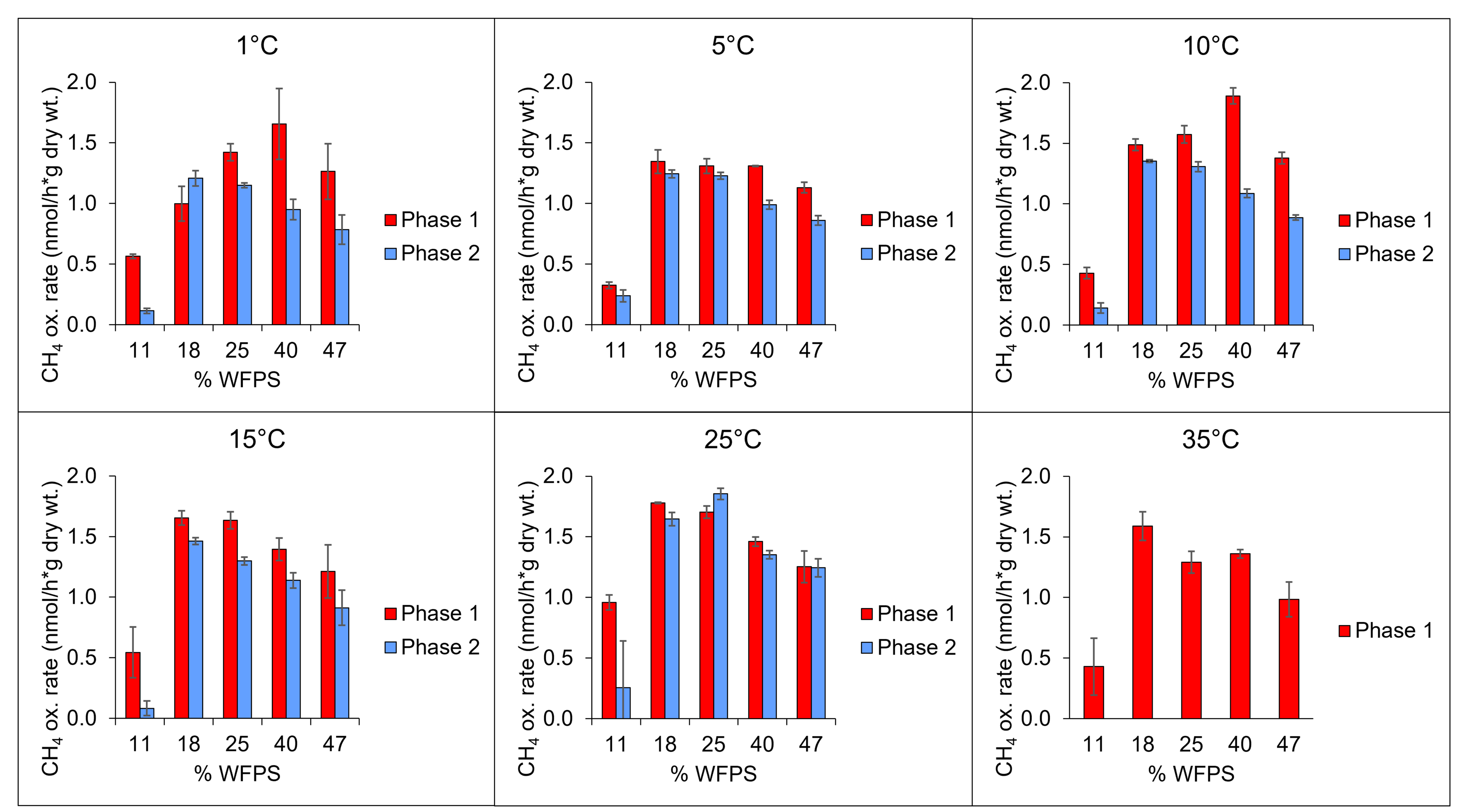
Sample T_0 and T_1 concentrations

CO_2 efflux rates: impact of temperature and WFPS



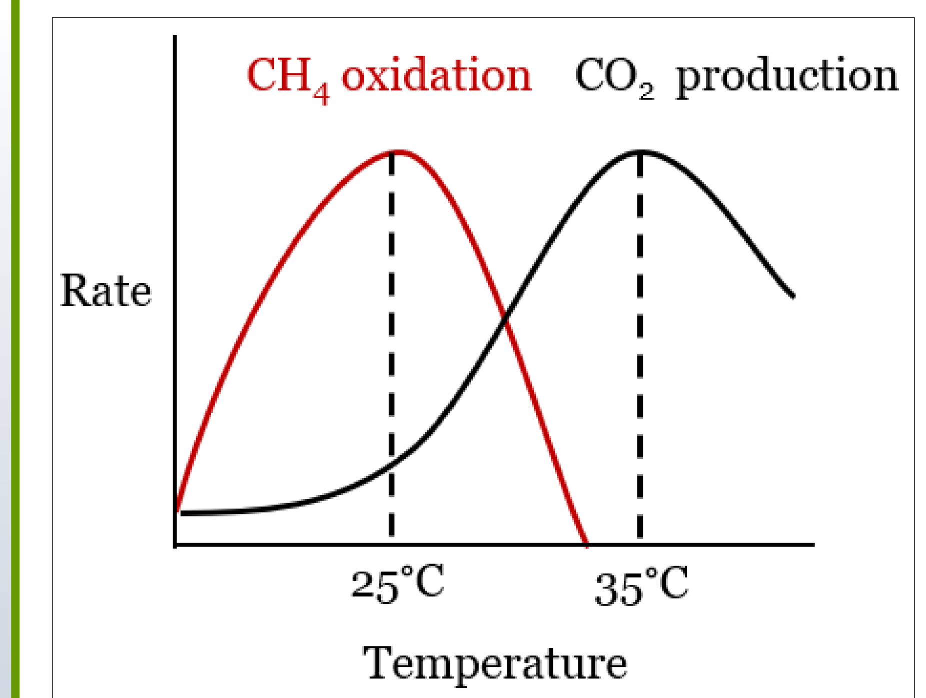
- Optimum temperature: 35°C
- Optimum WFPS: 47%
- Increase in CO_2 flux rates with both temperature and WFPS

CH_4 oxidation rates: impact of temperature and WFPS



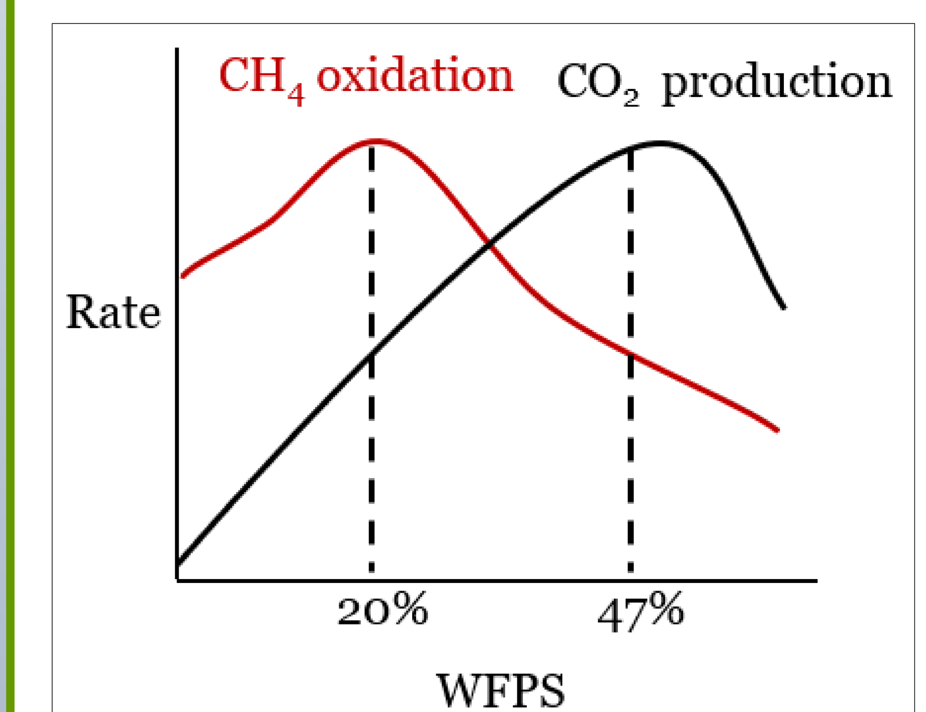
- Optimum temperature: 25°C
- Optimum WFPS: 40% at lower temperatures; 18-25% at higher temperatures
- At lower temperatures, CH_4 is more soluble → higher WFPS is favourable

Conceptual trends and conclusions



Conceptual trends in temperature

- **CO_2 efflux and CH_4 oxidation rates have different optimum temperatures:**
  - CH_4 oxidation rate peaks at around 25°C and decreases in Phase II of experiment
  - CO_2 production rate peaks at experiment's maximum temp. (35°C) → likely tapers after this



Conceptual trends in WFPS

- **CO_2 efflux and CH_4 oxidation rates have different optimum moisture contents:**
  - CH_4 oxidation peaks at intermediate WFPS conditions (approx. 20% in this experiment)
  - CO_2 production gradually increases with WFPS and peaks at experiment's maximum WFPS (47%) → true peak may be higher

- Experimental results provide insight into the effect of temperature and WFPS conditions, and therefore seasonal changes, on CH_4 oxidation
- Future work: optimize conditions for CH_4 oxidation and test amendments (*e.g.,* biochar) in mitigating CH_4 emissions from landfill cover soils

Acknowledgements

This research is funded by the Environment and Climate Change Canada's Climate Action and Awareness Fund (CAAF). We acknowledge the Hug Lab for their help in sample collection and experimental design. We also thank Marianne Vandergriendt and Dr. Shuhuan Li for their assistance with experimental design and laboratory analyses.

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