

The effect of soil moisture and oxygen content on naphthalene biodegradation

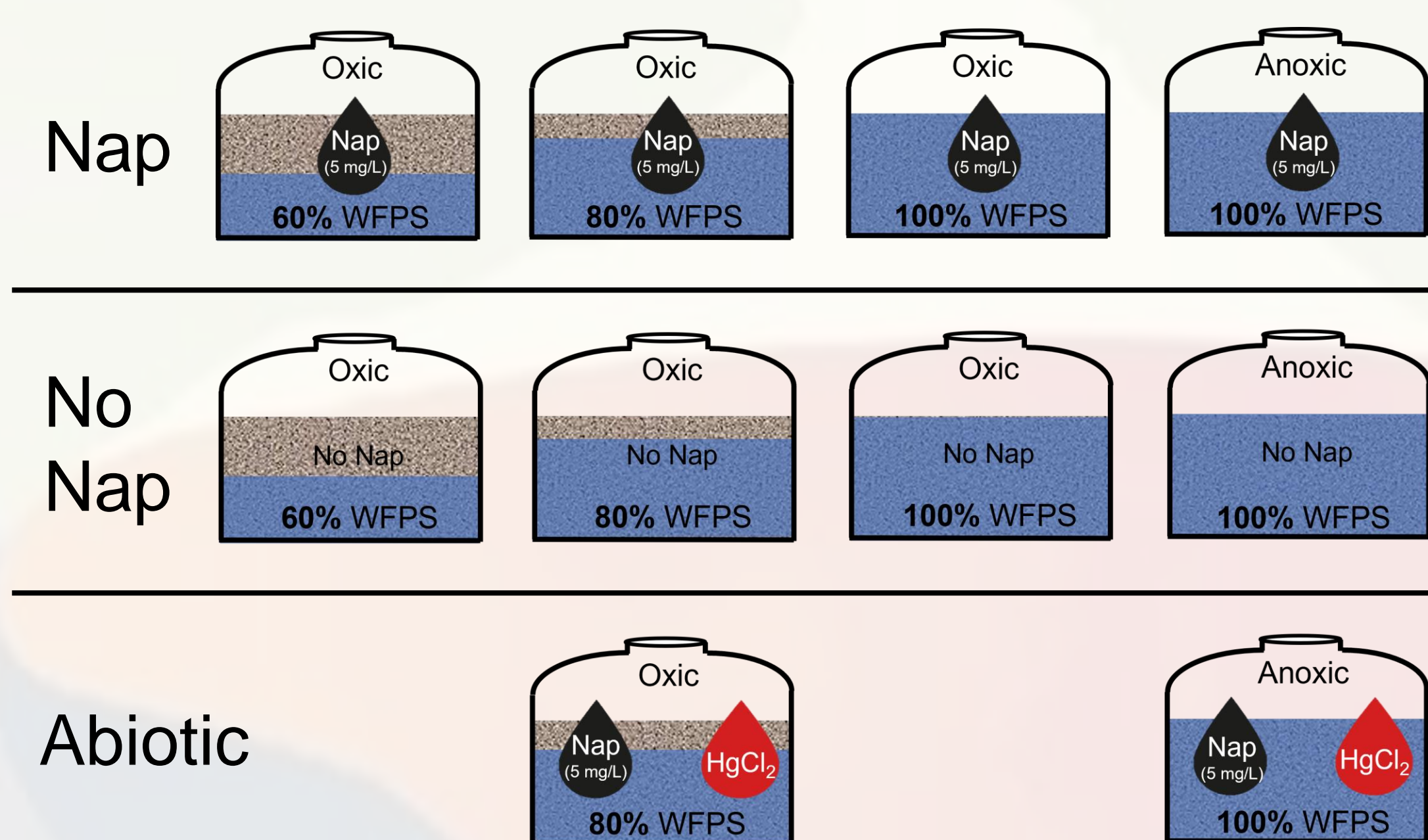
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Background

- Petroleum hydrocarbon (PHC) contamination of soil and groundwater threatens ecosystem health and groundwater resources worldwide^{1,2}.
- Natural attenuation processes of dissolved-phase PHCs include sorption, volatilization, and biodegradation³.

Incubation experiment

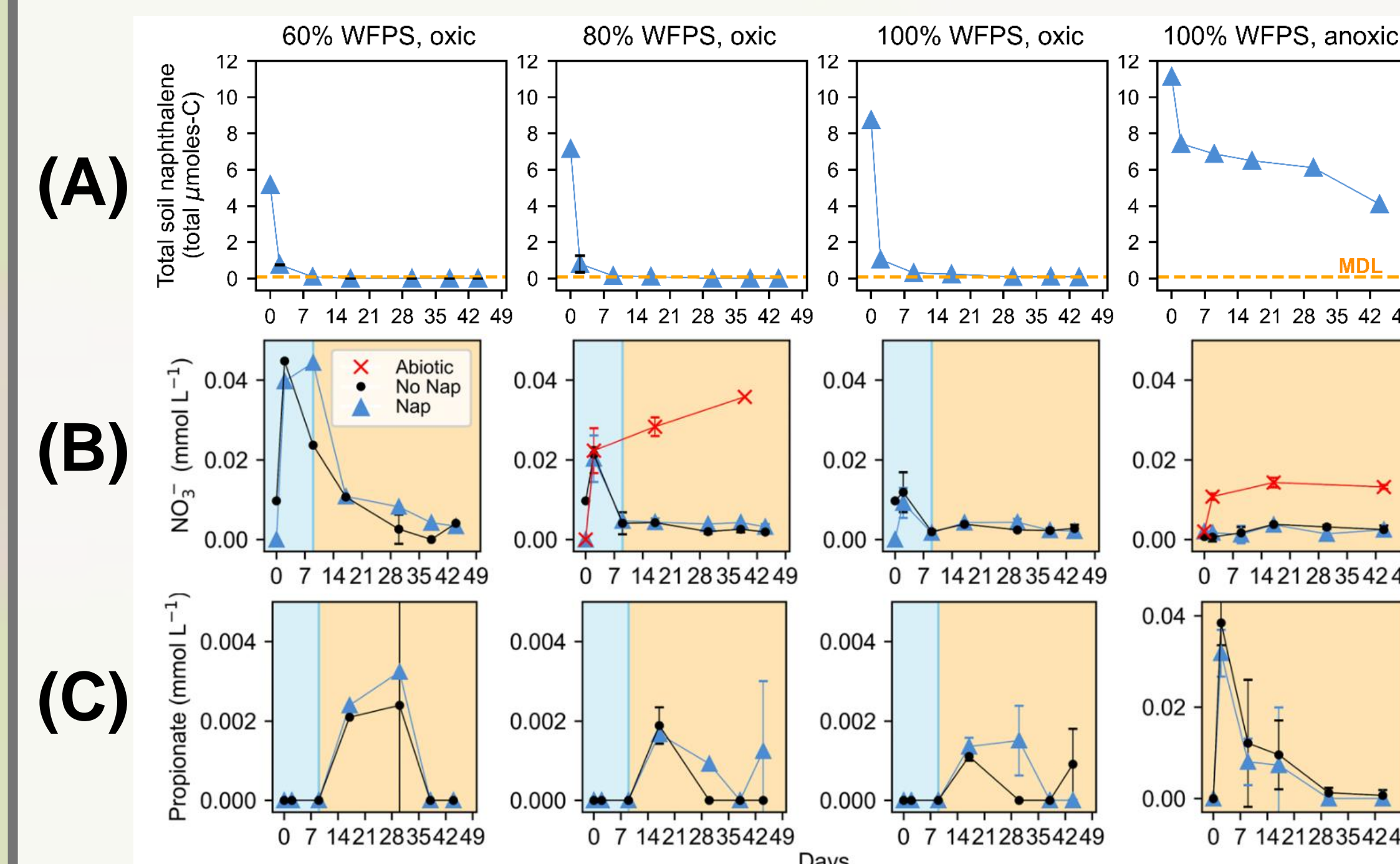


- Performed 44-day soil microcosm incubation under four soil-moisture/O₂ treatments: 60% water-filled-pore-space (WFPS) oxic, 80% oxic, 100% oxic, and 100% anoxic.
- Microcosms spiked with dissolved naphthalene (C₁₀H₈) as a representative PHC compound.
- Microcosms sacrificially sampled at weekly intervals, measuring porewater geochemistry and total soil naphthalene (via solvent microextraction and gas chromatography analytical method of SW-846 [Methods 3510 and 8270]).

References

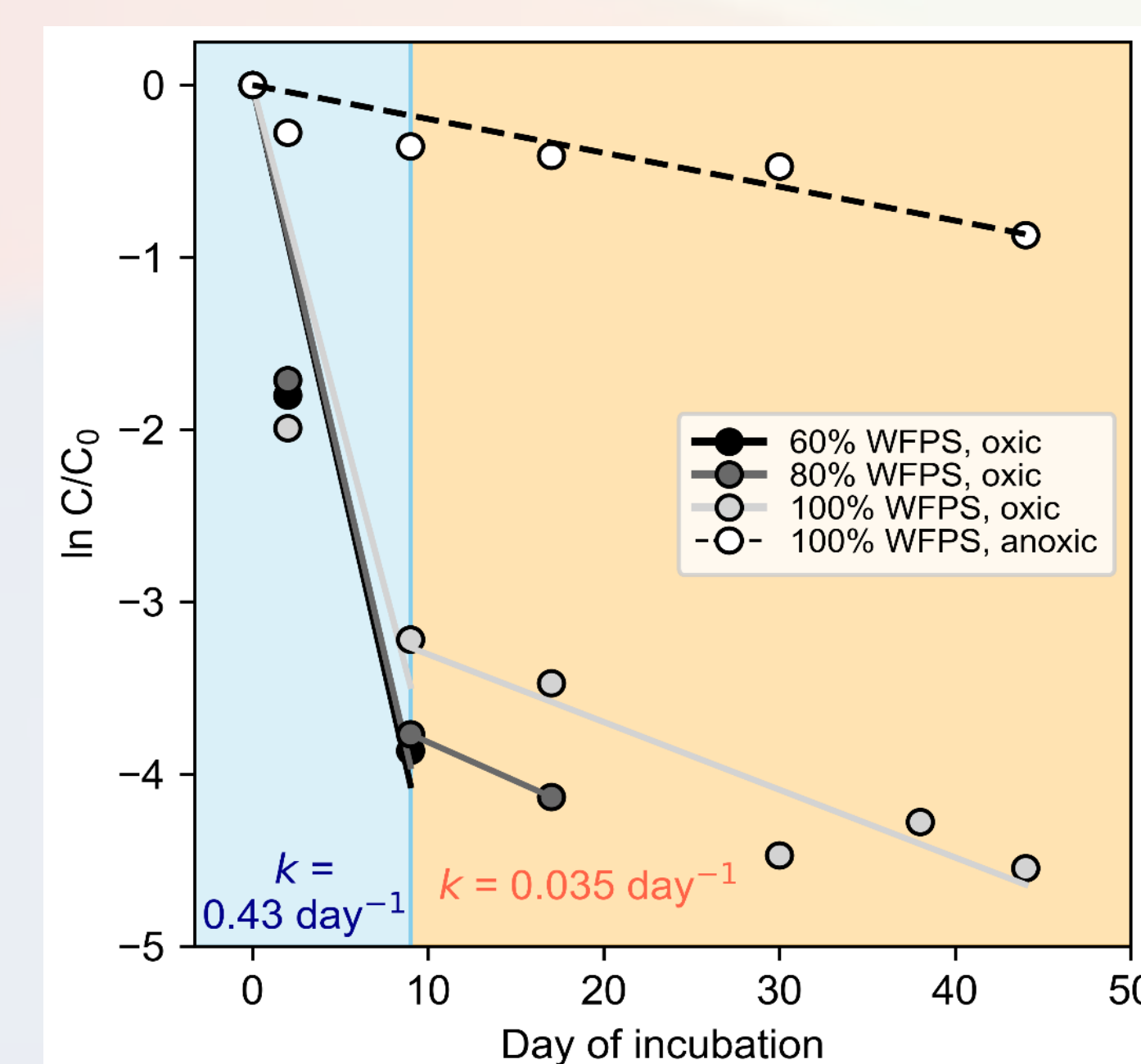
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Soil and porewater geochemistry



- Total soil naphthalene (A) decreases rapidly in oxic treatments.
- Majority of terminal-electron-acceptor (TEA) consumption occurs between Day 0-9 (B).
- Organic acid (OA) production begins in the slow kinetic phase (orange) (C).

Biodegradation kinetics



- Total soil naphthalene data was fit to 1st-order kinetic rate equation and distributed into fast (blue) and slow (orange) apparent rate constants (k).
- Dominance of respiration in fast regime evidenced by consumption of alternate TEAs.
- Dominance of fermentation in slow regime evidenced by production of OAs.
- Faster net biodegradation at low soil moistures controlled by greater contribution of fast kinetic processes.

Implications and current work

- Apparent k of naphthalene biodegradation varies by one order of magnitude across moisture/O₂ conditions found in vadose zone.
- Spatial and temporal variations in soil moisture and O₂ availability may lead to large variations in effectiveness of PHC natural attenuation at contaminated field sites.
- We are currently complementing this study with temperature-controlled incubation experiments to investigate temperature-dependence of fast and slow apparent k values of PHC biodegradation.

Biodegradation processes

- In the 60% WFPS oxic treatment, porewater O₂ is plentiful in the initial fast phase but is depleted along with alternate TEAs in the slow phase.
- Conversely, 100% anoxic treatment was O₂-limited initially; therefore, TEAs were consumed rapidly and only the slow regime was observed.

