Length of O_2 perturbation determines anaerobic rates of Fe^{III} reduction and CH_4 production

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Shifts between oxidizing and reducing conditions (redox fluctuations) are common in soils and sediments, and known to alter the pools of reducible Fe^{III}, mineralizable C, and the production of greenhouse gases. However, the characteristics of the fluctuations themselves (length, frequency, amplitude), and how they might impact biogeochemical rates are rarely examined. We hypothesized the rates of anaerobic (during τ_{anoxic}) Fe^{III} reduction and CH_4 emission would respond to the length of oxygen perturbation (τ_{oxic}). To test this hypothesis, we exposed a soil from the upper 15 cm of the Luquillo Critical Zone Observatory (LCZO), Puerto Rico, to three lengths of O2 perturbation cycles during repeated redox oscillations: a Long τ_{anoxic} of 6 d with variant τ_{oxic} of 8, 24, and 72 h (L-8, L-24, and L-72). We found that as the length of the preceding τ_{oxic} decreased from 72 to 24 to 8 h, anaerobic processes in the subsequent τ_{anoxic} shifted as follows: Fe reduction rates increased and CH_4 emissions decreased. We propose the short pulses of oxygen are not long enough to inhibit microbial Fe reduction, while longer O2 pulses stimulate microbial iron reduction and suppress methanogenesis. The length of oxidant exposure is thus a critical parameter for anaerobic processes that govern greenhouse gas emissions, contaminant mobility, and nutrient availability. One strategy for mitigating methane production and other consequences of anaerobic metabolism may be to control the length of oxygenation.