

Why does the efficiency of methane production vary dramatically among wetlands?

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Wetlands are critically important as an atmospheric source of methane (CH₄) and contain a substantial portion of the world's soil carbon. The accumulation of this soil carbon pool has largely resulted from inefficient anaerobic carbon cycling in these habitats. Methane emissions from wetlands have been sensitive to climate change in the past and may have strong feedbacks to future human-induced climate change. We have identified a number of biogeochemical mechanisms that are likely to determine the extent to which wetlands will respond to future climatic warming with enhanced CH₄ production – a key control of net CH₄ emissions. This project will determine the relative importance of these mechanisms in six wetlands that vary along a hydrogeomorphic gradient in northern Michigan.

The proportion of carbon that ends up as the two terminal end products of anaerobic mineralization -- carbon dioxide (CO₂) and CH₄ -- varies by several orders of magnitude among different types of wetlands, and the factors that control this variation are not well understood. Because of the high global warming potential of CH₄, the ratio at which these two gases are produced during anaerobic carbon mineralization can have a substantial impact on the Earth's radiative budget. ***The central objective of this project is to provide a quantitative understanding of four key controls on anaerobic carbon mineralization and the resulting ratio of CO₂:CH₄ produced in wetlands along a hydrogeomorphic landscape gradient. These factors are (i) the relative availability of inorganic and organic terminal electron acceptors (TEAs), (ii) the carbon quality of organic substrates that serve as electron donors, (iii) environmental factors (pH, temperature, nutrient availability), and (iv) microbial community structure.***

We propose three hypotheses that provide alternative explanations for the large observed variation in the CO₂:CH₄ ratio during anaerobic carbon mineralization. To evaluate these hypotheses, we will measure seasonal *in situ* CH₄ emissions, rates of acetoclastic and H₂/CO₂ methanogenesis, homoacetogenesis, and CO₂ production, and concentrations of TEAs and fermentation products in six wetlands along a hydrogeomorphic gradient. These data will be used to determine the thermodynamic favorability and, thus, likelihood of various anaerobic carbon mineralization pathways. Manipulative laboratory incubations will be used in conjunction with *in situ* measurements to evaluate how labile carbon availability, temperature, pH and nutrients control pathways of anaerobic carbon cycling and the CO₂:CH₄ production ratio in the same six wetlands. As part of these experiments, the role that humic substances play as TEAs will be assessed with both a mass balance and a novel direct measurement approach.

These detailed biogeochemical measurements of anaerobic carbon cycling will be integrated with molecular characterization of methanogen community structure. This work addresses a hypothesis that the variance in the ratio of CO₂:CH₄ production is due to environmental

tolerances of individual methanogen groups, which can not be explored with more traditional biogeochemical measurements alone. Our approach includes constructing a *mcrA* gene clone library, using the sequences in this clone library to design a terminal restriction fragment polymorphism protocol to distinguish among the major methanogen groups, and quantitative PCR to estimate the total abundance of methanogens in these same samples.