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Incorporating H2 Dynamics and Inhibition into a Microbially Based Methanogenesis Model for Restored Wetland Sediments

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Estimates of global CH4 emissions from wetlands indicate that wetlands are the largest natural source of CH4 to the atmosphere. In this paper, we propose that there is a missing component to these models that should be addressed. CH4 is produced in wetland sediments from the microbial degradation of organic carbon through multiple fermentation steps and methanogenesis pathways. There are multiple sources of carbon for methananogenesis; in vegetated wetland sediments, microbial communities consume root exudates as a major source of organic carbon. In many methane models propionate is used as a model carbon molecule. This simple sugar is fermented into acetate and H2, acetate is transformed to methane and CO_2, while the H2 and CO_2 are used to form an additional CH4 molecule. The hydrogenotrophic pathway involves the equilibrium of two dissolved gases, CH4 and H2. In an effort to limit CH4 emissions from wetlands, there has been growing interest in finding ways to limit plant transport of soil gases through root systems. Changing planted species, or genetically modifying new species of plants may control this transport of soil gases. While this may decrease the direct emissions of methane, there is little understanding about how H2 dynamics may feedback into overall methane production.

The results of an incubation study were combined with a new model of propionate degradation for methanogenesis that also examines other natural parameters (i.e. gas transport through plants). This presentation examines how we would expect this model to behave in a natural field setting with changing sulfate and carbon loading schemes. These changes can be controlled through new plant species and other management practices. Next, we compare the behavior of two variations of this model, with or without the incorporation of H2 interactions, with changing sulfate, carbon loading and root volatilization. Results show that while the models behave similarly there may be a discrepancy of nearly 50% of total CH4 production predictions depending on the inclusion of H2 interactions and other loading parameters. This discrepancy can have a meaningful impact on the estimates of total global CH4 emissions from wetlands, or even change the predicted carbon balance of specific wetlands. Overall, this model indicates the importance of H2 interactions in methanogenesis modeling, and may impact how we manage/design and construct wetlands for treatment or carbon sequestration.