Are Wetlands a Carbon Sink or Source? – From Microbes to the Globe

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Wetlands play a crucial role as global CO_2 sinks due to their high primary productivity and low decomposition rates. However, they are also significant sources of CH_4, a greenhouse gas with a radiative forcing 25 times greater than that of CO_2 on a molar basis. The net carbon balance of wetlands — whether they act as a sink or a source—is determined by the interplay between these opposing processes, which are strongly influenced by water level fluctuations. Despite their importance, the mechanisms governing these processes across different spatial and temporal scales remain poorly understood.

In this study, we quantified CO_2 and CH_4 fluxes in a freshwater marsh in Korea using an eddy covariance flux tower. To analyze these fluxes, we employed two complementary approaches. First, we examined microbial community structure and abundance through high-throughput sequencing and real-time qPCR, using these data to model soil organic carbon decomposition. Second, we developed a model to simulate CO_2 and CH_4 fluxes based on the CLM-FATES framework. Additionally, we constructed a machine learning-based model incorporating hyperspectral data and solar radiation to successfully simulate gross primary productivity. Our annual assessment revealed that the marsh functions as a net carbon sink, sequestering approximately 450 g CO_2-eq m^{-2} yr^{-1}, even when CH_4 emissions are accounted for.