Regulation of methane turnover and fluxes in marine and terrestrial systems

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Methane is a potent atmospheric greenhouse gas that has predominantly biological sources and is involved intimately in the global carbon cycle. The critical role of methane in global climate variation and regulation is clear and changes in biological methane sources and sinks strongly influence atmospheric methane concentration. Methane is actively cycled by a suite of interrelated microbial processes in marine and terrestrial habitats. The methane flux from a given habitat represents the balance between mehtane production in anaerobic zones and its consumption in either anaerobic or aerobic zones. Critical aspects of the factors regulating mehtane production and release from the environment remain poorly understood. Here, several key marine and terrestrial habitats – freshwater marshes, terrestrial saline lakes, estuarine sediments and methane-rich deep sea sediments – will be compared to elucidate the key factors that regulate methane flux and how these factors vary over space and time. Independent of habitat, carbon flow is controlled by microbially mediated processes, such as hydrolysis, fermentation, and terminal metabolism, which together serve to break down organic matter into its component building blocks. External and internal factors influence rates

Microbially-mediated sulfur cycling across diverse aquatic systems

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Sulfate reduction plays a key role in terminal orgnaic carbon oxidation in aquatic ecosystems. We studied the patterns, rates, and controls on sulfate reduction across a range of habitats in order to elucidate the factors regulating sulfur turnover and to identify key interactions between the sulfur cycle and other elemental cycles. Parallel molecular biological and microbiological studies aimed to link patterns of sulfur cycling with the responsible microorganisms. The systems studied – tidal freshwater sediments, sediments and waters from a terrestrial saline lake and from two permanantly ice-covered Antarctic lakes, and deep sea oil- and methane-rich sediments – encompass a broad range of availability of sulfate relative to organic carbon. In freshwater sediments, sulfate reduction (as determined in radiotracer experiments) was limited to a thin surficial zone (1-2 cm) but volummetric sulfate reduction rates comparable to those measured in carbon rich marine sediments (up to, and sometimes exceeding, 100 nmol cm^{-3} d^{-1}) despite extremely low sulfate concentration (<1 mM). The turnover time of the sulfate pool was <1 day, highlighting extremely efficient coupling between sulfur reduction and oxidation via both biotic and abiotic mechanisms. Increasing sulfate availability in these sediments resulted in a rapid increase in net sulfate reduction rates and more than doubled organic carbon remineralization rates. In ice-covered Antarctic lakes, sulfate reduction was regulated more by low temperatures and organic carbon supply than by sulfate supply. Sulfate redution rates in the water column of Mono Lake, a hypersaline alkaline lake in Northern California, were tightly coupled to seasonal cycles in labile organic carbon availability relative to methane availability. In Mono Lake sediments, sulfate reduction appeared to be limited by the avaialability of labile organic carbon. In deep sea cold seep sediments, the availability of labile organic matter strongly influenced sulfate reduction rates. However, similar to the situation in freshwater sediments, the rapid rates of sulfur cycling in cold seep sediments requires tight coupling between the oxidative and reductive sides of the sulfur cycle as well as physical mechanisms to increase the sulfate flux to the sediments. While the different environments studied here exhibited different abundance and composition of of sulfate reducing and sulfide oxidizing bacteria, the microbial communities at each site efficiently cycled sulfur and were able to respond rapidly to alterations in organic carbon or sulfate availability.