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Microbial Methane Oxidation Rates in Guandu Wetland of northern Taiwan

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Wetland is one of the major sources of atmospheric methane. The exact magnitude of methane emission is essentially controlled by microbial processes. Besides of methanogenesis, methanotrophy oxidizes methane with the reduction of various electron acceptors under oxic or anoxic conditions. The interplay of these microbial activities determines the final methane flux under different circumstances. In a tidal wetland, the cyclic flooding and recession of tide render oxygen and sulfate the dominant electron acceptors for methane oxidation. However, the details have not been fully examined, especially for the linkage between potential methane oxidation rates and in situ condition. In this study, a sub-tropical wetland in northern Taiwan, Guandu, was chosen to examine the tidal effect on microbial methane regulation. Several sediment cores were retrieved during high tide and low tide period and their geochemical profiles were characterized to demonstrate in situ microbial activities. Incubation experiments were conducted to estimate potential aerobic and anaerobic methane oxidation rates in surface and core sediments.

Sediment cores collected in high tide and low tide period showed different geochemical characteristics, owning to tidal inundation. Chloride and sulfate concentration were lower during low tide period. A spike of enhanced sulfate at middle depth intervals was sandwiched by two sulfate depleted zones above and underneath. Methane was accumulated significantly with two methane depletion zones nearly mirroring the sulfate spike zone identified. During the high tide period, sulfate decreased slightly with depth with methane production inhibited at shallow depths. However, a methane consumption zone still occurred near the surface. Potential aerobic methane oxidation rates were estimated between 0.7 to 1.1 μmole/g/d, showing no difference between the samples collected at high tide or low tide period. However, a lag phase was widely observed and the lag phase lasted over a longer period of time for the samples collected in high tide period. It seems that aerobic methanotrophs needed a longer period of time to recovery and/or had low activities, since they had been suppressed by low oxygen concentration during high tide period. The rates of anaerobic methane oxidation ranged between 1.5 and 4.0 nmole/g/d for samples collected at high tide period, whereas lower rates ranging from 0.2 to 2.0 nmole/g/d were observed for samples at low tide period. The addition of basal salt solution apparently stimulated methane consumption significantly. Based on the field observation and laboratory incubations, our results indicated a dynamic shift of metabolic zonation in tidally influenced wetlands. Aerobic methanotrophy appears to outpace anaerobic methanotrophy by orders of magnitude regardless of tidal inundation. This together with methanogenesis regulated by the availability of sulfate and organic degradation plays a major role in controlling methane emission. While anaerobic methanotrophy is relatively minor in methane cycling, its linkage with the sulfate availability modulates the coupling of carbon and sulfur turnover under anoxic conditions.