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Aerobic methane production in oxygenated water column of a lake ecosystem

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Methane is a potent GHG with about twenty times the global warming potential of carbon dioxide. Globally, half of CH_4 emissions are linked to industry and the extraction of fossil fuels, while the remainder of emissions is related to natural sources such as wetlands, freshwaters, oceans, forests, and termites. Among such various natural sources, lake ecosystems are now recognized as the important source of atmospheric CH_4, evading the 8-48 Tg CH_4 yr^{-1} (6-16% of total natural CH_4 emissions and greater than oceanic emission)(Bastviken et al. 2004). Therefore, identifying the pathways and mechanisms of CH_4 production in lake ecosystems is prerequisite to predict the GHG concentrations in the atmosphere and the resultant global warming in the future of the earth.

In lake ecosystems, the majority of methane production has long been believed to occur in anoxic sediments via methanogenesis. However, we have recently found the novel pathway of methane production in aerobic environments with well-oxygenated water in oligotrophic lakes. In particular, in lakes with phosphorus-deficient conditions, dissolved CH_4 concentrations often exhibit a large subsurface maximum during the stratified period. Moreover, seasonal occurrence of the CH_4 maximum was closely related to the abundance of planktonic microbes (such as *Synechococcus*) in the oxygenated water, suggesting active methane production by microbes even in the presence of O_2. Furthermore, the microcosm experiments confirmed the aerobic methane production when methylphosphonic acid (MPn) was added to the P-deficient lake water, suggesting the expression of *phn* genes encoding a carbon-phosphorus (C-P) lyase pathways for P utilization and producing methane from MPn. These findings are contradict to the conventional theory of methane production (methanogenesis in the absence of oxygen) but correspond to the recent findings on the aerobic CH_4 production in the North Pacific gyre (Karl et al. 2008); this study showed that marine microorganisms use MPn as a source of phosphorus when inorganic phosphate is scarce and generate CH_4 as a byproduct of MPn metabolism.

In this session, we will present such novel methane production pathway observed in an oligotrophic lake, central Japan. Spatial and temporal dynamics of dissolved methane and planktonic microbes, as well as the laboratory microcosm experiments show the causal relationships between aerobic microorganisms, their phosphonate metabolism, and aerobic methane production in lake ecosystems.

Keywords: Aerobic methane production, cyanobacteria, Synechococcus, methylphosphonic acid, P-deficient lake