Methanotrophic food webs in tropical lakes

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1. Introduction

Freshwater ecosystems are regarded as the primary source of atmospheric CH_4 which is 25-times more effective than CO_2 as a greenhouse gas. This estimation, however, could be biased because of limited knowledge on limno-physical and ecological processes of CH_4 cycling in tropical lakes. In tropical lakes which are meromictic, i.e., there is no mixing of surface and deep waters, CH_4 is stored in the deep anoxic waters, whereas its upward advection is hindered due to strong thermal stratification. To date, how much the CH_4 storage can contribute to the overall emission from the tropical lakes have been poorly understood for lack of intensive monitoring.

Since methane oxidizing bacteria (MOB) which assimilate dissolved CH_4 aerobically or anaerobically embed CH_4-derived carbon in consumer biomass through methanotrophic food webs (MFWs), they have great impacts on CH_4 cycling in lake ecosystems. Therefore, understanding of controlling mechanisms for the MFWs can also improve our estimation of CH_4 flux. Here we conduct monitoring survey for dynamics of CH_4, MOB and MFWs in tropical maar lakes of the Philippines.

2. Materials and Methods

We monthly monitored vertical profiles of physico-chemical environments in the Seven Lakes, which is a cluster of 7 volcanic crater lakes called ‘maar lakes’, located on the Luzon Island in the Philippines, from October 2016 to February 2019, using a CTD profiler. For the deepest three lakes (38, 62 and 156 m at depth for Yambo, Pandin and Calibato, respectively), we further measured dissolved CH_4 in 6-7 layers from surface to near-the-bottom waters. We also monitored vertical profiles of MOB and MFWs during the mixing season (February 2019), using NGS (Illumina Miseq), CARD-FISH and fatty acid analysis.

3. Results and Discussion

During the most of time, lakes experienced strong thermal stratification, except for the shallowest lake Palakpakin (7.7 m at depth) regarded as polymictic. During *Amihan*, which is Northeast Monsoon characterized by cool temperature and strong trade wind during months (December-March) shifting from wet to dry seasons, however, complete vertical mixing occurred in some lakes whose depth is 38 m or less. The correlation analysis for monthly data revealed that the thermal stratification was destructed with the decreasing air temperature rather than with the increasing wind speed, suggesting that temperature-driven advection is the primary limno-physical mechanism to cause vertical mixing in the tropical lakes.

Three deepest lakes had high CH_4 concentrations in hypolimnion, ranging from 670 to 1172 μmol/L near the bottom at the end of the stratification period, which shows high potential for CH_4 storage in the deep tropical lakes. During the Amihan, however, the CH_4 storage almost disappeared in Yambo due to the vertical mixing.

In these three lakes, MOB communities were composed mainly of three types, Type I and II, and NC10, while the NGS analysis revealed that a novel taxon, Methylacidiphilaceae, dominated in an epilimnion. Despite the high CH_4 concentrations and the presence of MOB, contribution of CH_4-derived carbon to zooplankton was low in these lakes, compared to that in non-tropical lakes, suggesting that MFWs do not function as carbon recycling so much in the tropical lake ecosystems.

To quantitatively estimate atmospheric CH_4 emission during the mixing event, more intensive monitoring and incubation experiment are needed to measure advection flux of stored CH_4 and CH_4 oxidation rate for the MOB.

Keywords: Methane, Methane oxidizing bacteria, Tropical lake, Meromictic lake, Methanotrophic food web