Seasonal change of photosynthesis of benthic communities in Antarctic lakes

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The most luxuriant vegetation is found in freshwater lakebeds as thick phytobenthic mats in East Antarctica. Although the almost Antarctic freshwater lakes are ultra-oligotrophic, this paradoxical situation is thought to result from that accumulation over time applies to photosynthetically produced biomass and also to nutrients. This allows luxuriant growths to develop, despite low temperatures, a short growing season, and low fluxes of nutrients from terrestrial catchments, making the benthic environment diverse and productive oases in polar desert. Seasonal changes of phytoplankton abundance have been sometimes reported in Antarctic lakes (Lizotte 2008; Tanabe et al. 2008), though phytoplankton is very sparse. On the other hand, the photosynthetic activities of benthic mats are measured well in many lakes and ponds on Antarctica during summer (Quesada et al. 2008; Tanabe et al. 2010), whereas little is known about it for a period from autumn–winter–spring.

To know the seasonal change of primary productivity of the benthic communities dominated in polar aquatic ecosystem, we collected phytobenthic mat samples by a gravity corer from Lake West Ongul (69°01'S, 39°33'E) in West Ongul Island, Sôya Coast, East Antactica once or twice per month during autumn–winter–spring from February to November 2017, from Lake Naga (69°29'S, 39°36'E) in Skarvsnes in every a week during summer from December 2007 to February 2008. Vertical limnological parameters; temperature, pH, DO (dissolved oxygen), conductivity, and Redox were measured by a multi-quality meter (proDSS, YSI) in the same position of sampling the benthic mat at every sampling. A mooring system was installed in Lake Naga for continuous monitoring of dynamics underwater such as PAR (photosynthetically active radiation) and temperatures using the several data loggers for all the year. After collecting the benthic samples, the samples transported to the base carefully not to freeze, then photosynthetic characteristics were measured using a chlorophyll fluorescence instrument (Phyto-PAM, Walz) as soon as possible after arrival in the base, and rest of the samples were frozen in the dark at -20°C for analyzing the pigments composition as an index of light-utilization and photo-community composition. PAR data underwater was used for estimation of possible maximum photosynthesis of the benthic mat.

The photosynthetic activities drastically changed seasonally. The photosynthetic productivity was thought to be the highest in summer because the most light energy is available of the year in this mid-night sun season, however the estimated maximum photosynthesis peaked in spring and autumn, and dropped to zero completely in April and continued zero until August, then, droped in mid-summer when the incident light energy suddenly increased due to disappearance of the lake ice-cover, but the value was quite low but positive and recovered toward early-autum in spite of the strong light condition still continuing. From the pigments composition, relative concentrations of photo-protective substances and quenchers of radical oxygen such as carotenoids and UV absorbing substances like MAA (mycosporine-like amino acid) and scytonemine increased after loss of the lake ice-cover and were continued to increase toward early-autumn. Therefore, the phytobenthic communities are thought to be able to recover their photosynthetic activities under continuous strong light condition. However, it should be high cost to synthesize such protective/quenching components and there would be a trade-off between photosynthetic activity and concentration of these components. So, for the future, we will continue to analyze pigment composition of the benthic samples taken during autumn–winter–spring, then we will aim to reveal the seasonal change of the relationship between the photosynthesis and pigment compositions.

References

Lizotte MP. Phytoplankton and primary production. In: Vincent FW, Laybourn-Parry J (eds). "Polar Lakes and Rivers", pp157-178, Oxford University Press, Oxford, 2008.

Tanabe Y, Kudoh S, Imura S, Fukuchi M. Phytoplankton blooms under dim and cold conditions in freshwater lakes of East Antarctica. Polar Biol. 31(2): 199-208, 2008.

Tanabe Y, Ohtani S, Kasamatsu N, Fukuchi M, Kudoh S. Photophysiological responses of phytobenthic communities to the strong light and UV in Antarctic shallow lakes. Polar Biol. 33(1):85–100, 2010.

Quesada A, Fernandez-Valiente E, Hawes I, Howard-Williams C. Benthic primary production in polar lakes and rivers. In: Vincent FW, Laybourn-Parry J (eds). "Polar Lakes and Rivers", pp179-196, Oxford University Press, Oxford, 2008.