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Photosynthetic activity and community structure in intertidal microbial mats

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Cyanobacteria are known as the first oxygenic photosynthetic bacteria, which played a major role in oxygenation of the earth's atmosphere. How they evolved oxygen-generating photosystems and have interacted with environmental change is key to an understanding of the history of early life and earth; but it has remained unclear. Here we integrate geochemical and molecular-biological studies of intertidal microbial mats to assess physiology and diversity of photosynthetic organisms. Microbial mats are a multi-layer of diverse benthic microorganisms, often dominated by phototrophic bacteria. They are distributed in a wide range of habitats, including marine intertidal flats that experience strong fluctuation of oxygen/sulfide concentrations, hence serve as a modern model system suitable for the study of cyanobacterial response to the redox shift in the past.

Microbial mats were sampled from two sites located in the sandy beach facing the North Sea, in the Dutch barrier island Schiermonnikoog. The materials used in this study were collected in early and mid summer, to make comparison between seasons as well as locations. In order to investigate the effect of redox conditions on phototrophic activity, the mats were incubated with $H^{13}CO_3^-$ under up to 16 different growth conditions in a temperature- and light-controlled room, and were freeze-stored until RNA extraction. Group-specific rRNAs were captured using magnetic beads with biotin-modified probes to link taxonomic distribution directly with physiological property.

Phylogenetic analysis of 16S rRNA clone libraries confirmed high taxon specificity of the oligonucleotide probes used in this study. It showed that the mats examined here were predominated by non-heterocystous filamentous cyanobacteria (Oscillatoriales), together with minor fractions of heterocystous (Nostocales) and coccoid (Chroococcales) species. Stable isotope measurement of the isolated rRNA indicated carbon fixation in all tested materials, and higher ^{13}C incorporation into cyanobacterial rRNA was observed when the mats were grown under anoxic conditions. Their photosynthetic activity diminished, but was not completely blocked, by addition of DCMU, an inhibitor of PSII, indicating possible contribution of PSI dependent photosynthesis in the system. Increase of sulfide concentration, however, did not enhance physiological activity, possibly due to inhibitory effect of excess sulfide on biological metabolism.

Continuing study of microbial communities under redox fluctuating environments will provide us a clue to an understanding of not only evolutionary process of photosynthetic organisms but also its interrelation with early biosphere.

Keywords: microbial mats, cyanobacteria, redox condition, stable isotope, diversity, RNA