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Light dependent differences in the architecture of freshwater phototrophic biofilms

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Biofilms as interfacial attached microbial communities are widespread at surface and subsurface habitats and may be considered as mediatory elements between lithosphere, hydrosphere and atmosphere. In case of phototrophic biofilms metabolism is mainly driven by light as energy source for photosynthesis. Different effects of biogeochemical cycling can be expected depending on physiological activity of attached organisms and functioning of the EPS matrix. The purpose of this investigation was to determine temporal development, structure and species composition of freshwater phototrophic biofilms under low (30 μmol m^{-2} s^{-1}) and high (120 μmol m^{-2} s^{-1}) light intensities. Long-term (1 to 3 months) laboratory experiments were carried out in a special flow-lane incubator with precise control of light, temperature and velocity. Structure and architecture of phototrophic biofilms were analysed at different stages of development (initial settlement, active growth and mature stage) by using confocal laser scanning microscopy (CLSM). Furthermore, horizontal and vertical distribution of biofilm constituents (phototrophic and heterotrophic organisms and glycoconjugates of EPS matrix) were examined by CLSM in intact areas and in areas after massive sloughing events in order to characterize surface and base layers of matured biofilms. For comparison, biomass development was analysed by employing gravimetric methods. Phototrophic biofilms were dominated by chlorophytes under high light conditions whereas cyanobacteria and chlorophytes were the main phototrophic organisms at low light conditions. Not surprisingly, growth and biomass development were clearly light-dependent. Under high light conditions matured biofilms reached an areal density of 40 g m^{-2}, a biofilm thickness of 700 μm and the base biofilm contained less than 3% of total biomass. Under low light conditions matured biofilms had a lower areal density (15 g m^{-2}) and biofilm thickness (500 μm), but the base biofilm

reached up to 25% of total biomass. Mineral content (30%) of the base biofilm was 2 times higher at high light intensity. Higher organic content (85%) and a 6 times higher EPS to Chl A ratio of base biofilm at low light intensity may indicate a strong persisting pattern of biofilms developed under these conditions. In conclusion, CLSM can be used as a powerful tool to quantitatively determine the structure and distribution of different constituents in phototrophic biofilms. After quantification of digital image data the information may be used to develop a mechanistic model for phototrophic biofilms. The structural features of phototrophic biofilms may serve as a basis for understanding the development and maturation of environmental biofilms grown under different light regimes. Finally, artificial phototrophic biofilms may represent a model system for understanding the development of other more complex phototrophic biofilms such as microbial mats and stromatolithes.