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Limnological Investigations and the Use of Photosynthetic Pigments As Proxy of Photoautotrophic Communities in Antarctic Lakes and Soils

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Abstract

The Victoria Land represents one of the most interesting yet understudied limnological areas of Antarctica, except for the Dry Valleys. In the present thesis, the spatial and temporal trends in water quality, sediment characteristics and photoautotrophic activity were explored in 55 lakes and ponds, under different climatic and environmental conditions in ice-free areas of this region. The aim was to investigate the lacustrine conditions and identifying environmental variables which influence chemical and biological lake properties, to make a preliminary investigation of the temporal dynamics and to validate the use of photosynthetic pigments as proxy in the study of terrestrial algal communities.
Short temporal dynamics of water quality were examined in sixteen lakes over five austral summers. Monthly changes in chemical and biological water characteristics were examined in a single lake undergoing an important reduction in water level over the last decade. Long-term trends were studied using a paleolimnological analysis of past photoautotroph communities of two lakes conducted on sediment cores using photosynthetic pigments as proxy for algal communities. As soil algae are the main primary producers in most terrestrial ecosystems in Antarctic continent, the relative proportion and distribution of different taxa in relation to changing biotic and abiotic factors were examined using photosynthetic pigments.
Spatial trends in water chemistry showed that the composition of lakes and ponds mainly reflected that of seawater, although a wide range in ion concentrations was observed. The input of elements from the marine environment decreased with distance from the sea and there was an increase in nitrate and sulfate concentrations from the coast to inland. During the five-year monitoring survey, no statistically significant variation in the water chemistry was detected, except for a slight increase in total nitrogen concentrations. Additional factors that were found to affect water quality in the Antarctic cold desert environments were the presence of nesting seabirds, the percentage of ice-cover and the sampling time. By comparing monthly changes in icecover and pigment concentrations in the water column, it was shown that changing solar irradiance created conditions where aquatic organisms metabolized protective substances to reduce their overall exposure to solar ultraviolet radiation. The contemporary decrease in primary productivity with increased ultraviolet radiation exposure suggested that ice-cover and solar irradiance were key variables controlling primary productivity of phytoplankton during the austral summer. The main phytoplankton divisions were Cyanophyta, Crysophyta and Chlorophyta with a limited number of Euglenophyta and diatoms. This pattern was also confirmed by HPLC pigment analysis. Several new genera of algae were identified by microscopy in Lake 14 (Edmonson Point).
Pigment concentrations in surface sediments and microbial mats were comparable to those reported for other Antarctic lakes. Cyanophyta, Chlorophyta, Bacillariophyta and purple bacteria were the main taxa identified confirming information reported in microscopy-based studies of Antarctic phytobenthos. Redundancy Analysis of data indicated that water chemistry was the main factor affecting pigment distribution in the Victoria Land mats, whereas latitude and altitude were the main factors affecting the sedimentary pigment distribution. Even if primary productivity and diversity showed a statistically significant negative correlation with the latitude, the effect of environmental variations due to latitude appears to be mediated by local physical and biological conditions. Discriminant Function Analysis showed that lacustrine chemistry and biology were mainly determined by their geographical location; however, further research is required to single out other unknown factors affecting the composition of lacustrine waters and photosynthetic pigments in Antarctic cold desert environments.

Analysis of fossil pigments revealed a higher primary production in the top centimeters of two sediment cores and a higher UV-R availability in recent decades. A shift in the relative abundance of the marker carotenoids was measured in the stratigraphic profiles.
Photosynthetic pigments extracted from soil of Victoria Land were shown to be a good proxy for the main structural features of the algal community. The pigment distribution reflected differences in the relative proportions of Chlorophyta, Cyanophyta and Bacillariophyta in the studied sites. Multivariate analysis indicated that the most important environmental variables affecting the pigment distribution were water content, total and organic carbon, total nitrogen and electrical conductivity. With the results of the present analyses, we have shown that pigment concentrations can be used to study the relationships between environmental variables and algal distribution in continental Antarctic soils.