Unveiling the ecological significance of algal mats and meadows: Insights into phosphorus cycling and primary production of benthic algae in post-mining lakes

Klara Rehakova[‡,§], Kateřina Čapková[‡,§], Eliška Konopáčová[‡], Jiří Nedoma[‡], Jan Mareš[‡], Tomáš Bešta[‡], Lenka Štenclová[‡], Andreja Kust[|]

‡ Biology Centre v.v.i., Institute of Hydrobiology, České Budějovice, Czech Republic
§ Institute of Botany, Třeboň, Czech Republic
| UC Berkeley, Innovative Genomics Institute, Berkeley, United States of America

Corresponding author: Klara Rehakova (krehakova@email.cz)

Abstract

Post-mining lakes are anthropogenic water bodies increasing globally due to mining suppression and recultivation. These lakes have ecological and socioeconomic significance, providing freshwater sources, wildlife habitats, and recreation potential. However, research on primary producers in these lakes is limited, with most studies focusing on phytoplankton while neglecting algal mats and meadows. If developed in high biomass, algal mats and macroalgal meadows play a crucial role in aquatic ecosystems. They contribute to the trophic structure, nutrient fluxes, primary production and to the purification of entire waterbodies. Yet, there is a lack of knowledge regarding the nutrient acquisition and the contribution of algal mats and meadows to total primary production and phosphorus (P) cycling, especially in oligotrophic lakes, including post-mining lakes. Our team investigates the benthic algal primary producers - algal mats and meadows in the littoral zone of tree newly established post-mining lakes located in the Czech Republic (Europe). Our main objectives are to describe the quality and quantity of primary producers, quantify the contribution of algal mats and meadows to the primary production and phosphorus cycling in the oligotrophic post-mining lakes. We have studied them throughout all seasons with a special focus on the generally neglected winter/spring season. Our sampling strategy encompasses three gradients of variability along which the composition and ecological role of benthic algae change:

1. spatial variability along the depth gradient within each lake,
2. *i*temporal variability throughout the seasons within each lake and
3. successional variability between the lakes of different age.

The methodological approach consists of measuring the limnological and chemical parameters of lakes, taxonomic determination, biomass estimation and C:N:P stoichiometry of algal biomass along the whole gradient of the euphotic zone (0-15m). The in situ measurement of primary production of benthic algae from various depths using the oxygen meter Fibox 3 (PreSens, Germany) with a combination of laboratory experiments was employed too (Čapková 2022). We measure the kinetic parameters of P uptake of algal mats and meadows using ^{33}P-labelled orthophosphates under controlled conditions similar to the nature (Konopáčová 2021). According to our survey, algal mats and meadows exhibited high productivity in the entire littoral zone. Algal mats dominate the depth up to 3m Fig. 1 and are highly diverse, with more than 400 identified taxa (Bešta 2022). Macroalgal meadows formed by the genus *Chara* together with the genus *Vaucheria*, are key taxa occupying the deeper zone (3-15m) Fig. 2. The distribution of benthic algae in lakes is influenced by depth gradients, substrate quality, seasonality and age of lakes foundation, resulting in complex spatio-temporal patterns. Specific emphasis is placed on the fate of P, which is the limiting nutrient in investigated lakes. High C:P molar ratios in microalgal mats indicate strong P deficiency in studied lakes. Over the vegetation season, microalgal biomass doubled, while the P content in biomass dropped to 60% of the values from the start of the vegetation season. The maximum uptake velocity and specific P uptake affinity decreased by an order of magnitude from April to October, and P uptake affinity was measured for comparison in plankton too. Based on our results, we proposed a possible mechanism underlying a stable coexistence of planktonic and benthic primary producers, with plankton prospering primarily in summer and autumn and algal mats and meadows in winter and spring seasons. By integrating data collected during five years of investigation, our study aims to provide a comprehensive understanding of the ecological roles of primary producers in post-mining lakes.

Keywords

periphyton, *Chara*, *Vaucheria*, ecophysiology of benthic algae, seasonality, oligotrophic lakes, recultivation

Presenting author

Klára Řeháková

Presented at

oral presentation in Part 4: Emerging Tools & Areas of Scientific Inquiry

Acknowledgements

Acknowledgements for funding: Czech Science Foundation (GACR 19-05791S), Czech Academy of Sciences within the program of Strategy AV 21, Land save and recovery.

Conflicts of interest

The authors have declared that no competing interests exist.

References

- Bešta T, et al. (2022) Littoral periphyton dynamics in newly established post-mining lakes. Aquatic Sciences 85 (1). https://doi.org/10.1007/s00027-022-00914-y
- Čapková K, et al. (2022) A Low-Cost Method of Measuring the *In Situ* Primary Productivity of Periphyton Communities of Lentic Waters. Journal of Visualized Experiments 190 https://doi.org/10.3791/64078
- Konopáčová E, et al. (2021) Low Specific Phosphorus Uptake Affinity of Epilithon in Three Oligo- to Mesotrophic Post-mining Lakes. Frontiers in Microbiology 12 https://doi.org/10.3389/fmicb.2021.735498

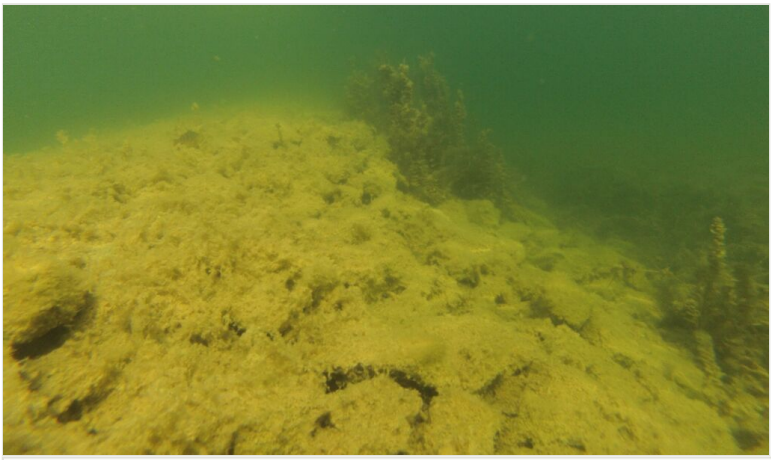

Figure 1.

Algal mats from one of the studied post-mining lakes in the Czech Republic dominating the littoral zone up to 2 m depth.

Figure 2.

Macroalgal meadow formed by the genus *Vaucheria* from one of the studied post-mining lakes in the Czech Republic, occupying the deeper part of the littoral zone up to 15m depth.