Seasonal variation of gross ecosystem productivity of periphyton in three post-mining lakes in the Czech Republic, Europe

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Abstract

We investigated the seasonal variation of gross ecosystem productivity (GEP) of periphyton biomass in three post-mining lakes in the Czech Republic. These lakes were established as part of recultivation efforts after coal mining activities and resulted in a unique series of anthropogenic oligotrophic lakes of gradual successional age. Periphyton is ubiquitous in aquatic habitats and performs numerous environmental functions such as nutrient cycling and self-purifying of aquatic ecosystems. Well-developed periphyton mat can be formed within a few weeks, so it can quickly become the dominant of littoral zone of newly established lakes. In studied post-mining lakes, the highly developed periphytic community covers the littoral zone of each lake to the depth of 2m (Bešta et al. 2022, Konopáčová et al. 2023) Fig. 1.

We aimed to shed some new light on the processes controlling the dynamics of primary productivity in oligotrophic lakes. The accurate estimation of primary productivity is crucial for understanding the functioning of aquatic ecosystems, as primary productivity serves as the primary source of autochthonous carbon in these systems. In addition to phytoplankton, periphyton can significantly contribute to primary productivity in littoral zones, known for their high productivity and biodiversity. Conducting *in situ* measurements provides the most accurate means of inferring the metabolic activity of primary producers in littoral zones.

We conducted detailed seasonal *in-situ* periphyton gross primary production (GPP) measurements in three post-mining lakes with different successional ages (Čapková et al. 2022). GPP and NPP of periphytic biomass were determined using direct *in-situ* measurement of O_2 fluxes. O_2 production and consumption were measured over 5 hours of *in-situ* light and dark gas-tight glass bottle incubation. Bottles were filled with the lake water from the corresponding depth, and a similar amount of periphytic biomass was enclosed Fig. 2. We used the Fibox3 fibre-optic oxygen meter coupled with a PSt3 oxygen sensor

(PreSens, Regensburg, DE) to measure changes in O_2 concentration. The O_2 fluxes were normalized to periphytic biomass in each bottle (measured as total organic carbon). Data were corrected for O_2 concentration changes in dark and light gas-tight bottles containing lake water without periphytic communities.

This setup enabled us to monitor online oxygen flux, therefore, insights into metabolic activities. The primary productivity was measured in real-time, allowing us to capture the quantitative effect of various environmental drivers on periphyton productivity, i.e. phosphorus concentration and light intensity, as they are known to play significant roles in primary productivity.

We showed that the primary production of periphyton mats exhibited seasonal variations, with higher productivity observed in spring compared to other seasons. This observation could be attributed to the occurrence of winter/spring upwelling events and vertical mixing, which resupply nutrients from the deeper strata. Furthermore, the physiological activity of periphyton was strongly influenced by the seasonal changes in light intensity, temperature, and nutrient concentration.

We provided the first insight into the seasonal variation of primary productivity of the periphyton assemblage dominating the littoral zone of newly established post-mining lakes. We stress the importance of periphyton in aquatic ecosystems, particularly in anthropogenic oligotrophic lakes.

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Presented at

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

Conflicts of interest

The authors have declared that no competing interests exist.

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Figure 1.

Sampling of the highly developed periphytic community, which covers the littoral zone of studied post-mining lakes to the depth of 2m.

Figure 2.

In-situ measurement of periphytic O_2 fluxes. In-situ incubation of periphytic biomass under natural conditions of respective depths.