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Floatovoltaics, Warming Summers, and Freshwater Resilience

Experimental Responses of Phytoplankton Cell Density and Evaporation to Partial Surface Shading

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Key Takeaway: FPV shading consistently reduced evaporation across the tested temperature conditions, while phytoplankton responses were highly context-dependent and did not consistently suppress potentially harmful cyanobacteria.

1. Introduction & Context

To help meet ambitious renewable energy and net-zero targets without using more land, Denmark and other Northern European countries are exploring Floating Photovoltaics (FPVs). These are solar panels placed directly on freshwater bodies such as reservoirs, gravel pit lakes and agricultural ponds. FPVs could provide two main benefits: producing renewable energy and reducing water loss through evaporation by covering part of the water surface.

However, climate change is expected to bring more frequent and longer periods of high summer temperatures across Scandinavia. It is therefore important to understand how FPV shading and warmer water temperatures may interact and affect freshwater ecosystems, particularly evaporation, water temperature and stratification, and the risk of cyanobacterial blooms.

2. Experimental Methodology

A 21-day climate chamber experiment was carried out to investigate how different water temperatures and levels of FPV shading interact. Three freshwater phytoplankton species were tested: the green alga *Tetradesmus obliquus*, the bloom-forming cyanobacterium *Microcystis aeruginosa*, and the diatom *Cyclotella meneghiniana*.

The experiment used three temperatures (20.0°C, 22.5°C and 24.5°C) to represent different levels of present and future warming, together with three FPV shading levels of 10%, 25% and 50% surface coverage. Water loss through evaporation was measured throughout the experiment, while changes in phytoplankton cell density were monitored using manual light microscopy and, later in the experiment, a Muse Cell Analyser.

3. Evaporation Control & Thermal Hydrology

FPV helped reduce water loss through evaporation at all three temperatures tested. The link between shading and reduced evaporation was strongest at 22.5°C and 24.5°C, where more shading clearly led to less water loss. Overall, higher FPV coverage meant lower evaporation. The most pronounced effect appeared at 22.5°C, where increasing FPV coverage produced the largest reduction in water loss. At 20.0°C and 24.5°C, the biggest drop in evaporation occurred at the highest shading level of 50% coverage. This indicates that, under certain temperature conditions, relatively high FPV coverage may be necessary to achieve meaningful water-saving benefits.

4. Phytoplankton Responses & Cyanobacterial Bloom Risk

In contrast to evaporation, phytoplankton responses were more varied and depended on both species and temperature. *Tetradesmus obliquus* showed strong early growth under 10% shading at 22.5°C, but at 24.5°C it grew better under higher shading levels of 25–50%. This suggests that increased shading may become more beneficial for this species under warmer conditions. *Microcystis aeruginosa* displayed a marked increase in cell density under 25% shading at 24.5°C during the later part of the experiment. This indicates that moderate FPV shading, combined with warmer temperatures, could create favourable conditions for cyanobacterial growth. *Cyclotella meneghiniana* performed best under 50% shading at 20.0°C, while differences between shading levels became less distinct at higher temperatures. Overall, the results show that phytoplankton responses to FPV shading are species-specific and can shift depending on water temperature.

5. Water Resource Management & Policy Implications

The findings are relevant for water utilities, energy companies, municipalities and environmental authorities, including organisations such as HOFOR and floating solar developers operating across Scandinavia.

1. **Water conservation:** FPV systems can reduce evaporation and help protect freshwater resources, particularly during warmer and drier summer periods.
2. **Ecological monitoring:** Some shading levels may favour certain phytoplankton species under warmer conditions, highlighting the importance of monitoring light availability, water mixing and nutrient conditions when deploying FPV systems.

6. Conclusion

Floating solar technology offers strong potential for climate mitigation and water volume retention. However, long-term water quality assurance requires holistic management strategies rather than assuming universal ecological benefits.