Impact of floating solar panels on surface water quality for drinking water production

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INTRODUCTION: OPPORTUNITY FOR THE USE OF FLOATING SOLAR PANELS ON WATER RESERVOIRS

Floating solar panels offer an efficient opportunity for electricity production where available land space is limited. The increased efficiency of electricity generation is due to less extremes of temperature from immersion in water and the relative ease of rotating the panels to face the sun, allowing more energy produced than a similar system inland.

Drinking water utility PWN (the Netherlands) intends to install floating solar panels on an open reservoir for surface water storage before treatment, with a coverage of up to 50% of the total surface of the reservoir. With about 50 ha of reservoir surface, this solution seems very attractive for PWN. However, floating solar panels have side effects which may impact water quality in the reservoir, such as reducing water mixing by wind, creating local growth of algae or mussels on the underneath surface of the panels, or reducing light input into the water. Light is an essential energy source for algal growth, therefore a reduced light input may have significant impact on algae survival and growth in the reservoir, in turn impacting the organic and inorganic matrix of the water.

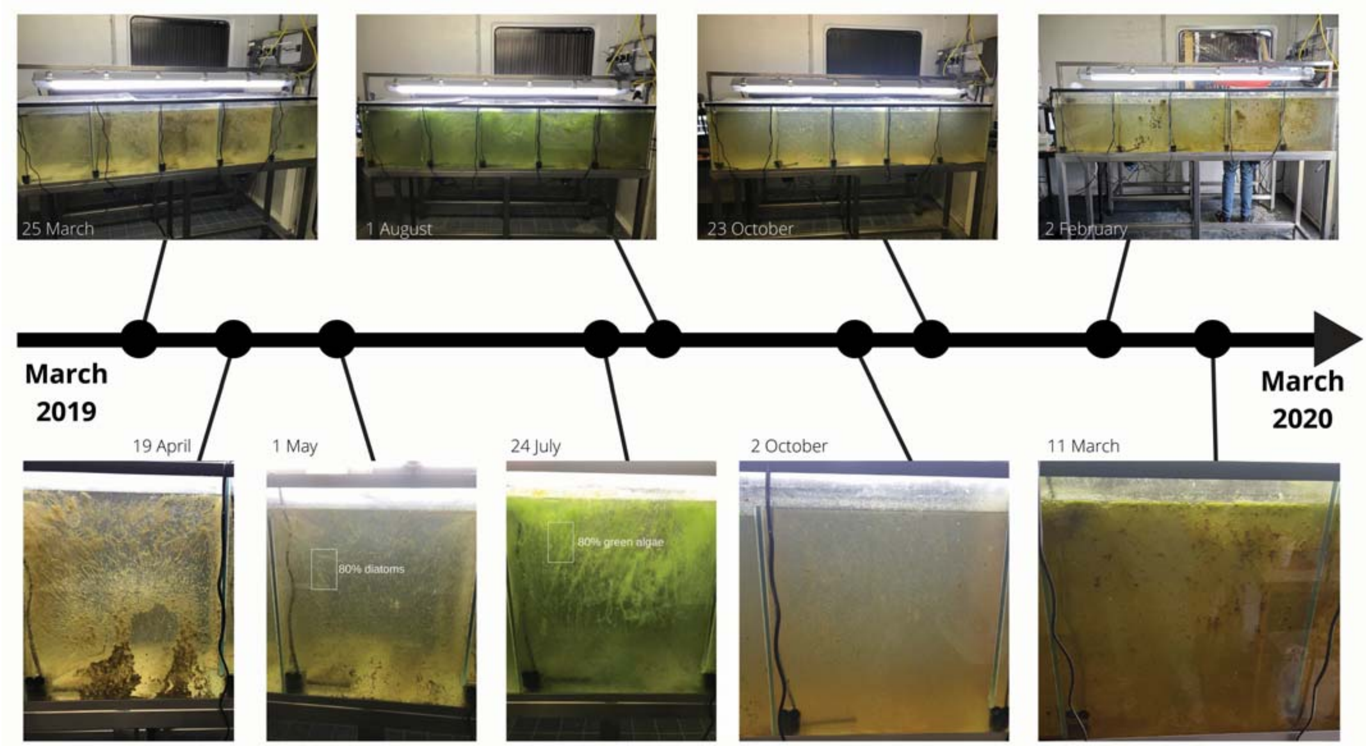

Figure 1: Experimental set-up made of two glass aquaria, one illuminated and one fully kept in the dark; The changes in algal concentration and composition in the illuminated aquarium are illustrated here

METHODOLOGY: CONTROLLED LABORATORY STUDY USING AQUARIA

In a controlled laboratory study, researchers from PWN's daughter company PWNT investigated the effect of reduced light input on water quality after storage of surface water in open reservoirs. The study was performed at a full-scale drinking water facility treating water from the shallow Lake Ijssel, stored in an open reservoir with a depth of 20m and with vertical air mixing. Two large glass aquaria were fed with lake water with a residence time in the aquaria similar to the average residence time in the full-scale reservoir. One aquarium was illuminated with a day/night cycle by a lamp with a light spectrum and intensity close to day light to simulate normal light conditions (Figure 1). The other aquarium was made of black glass and kept in the dark for the entire study, to simulate conditions under the floating solar panels.

Water quality was monitored for one year from the raw water, from the effluent of both the full-scale reservoir and the two aquaria. The algal concentration was monitored through total chlorophyll and a grouping into four different algal groups (green algae, diatoms and dinoflagellates, cyanobacteria and cryptophyta) was made once per hour with an online sensor. Water quality was controlled biweekly based on organic matter concentration and composition, as well as phosphate, nitrate, ammonium, bicarbonate and silicate concentrations.

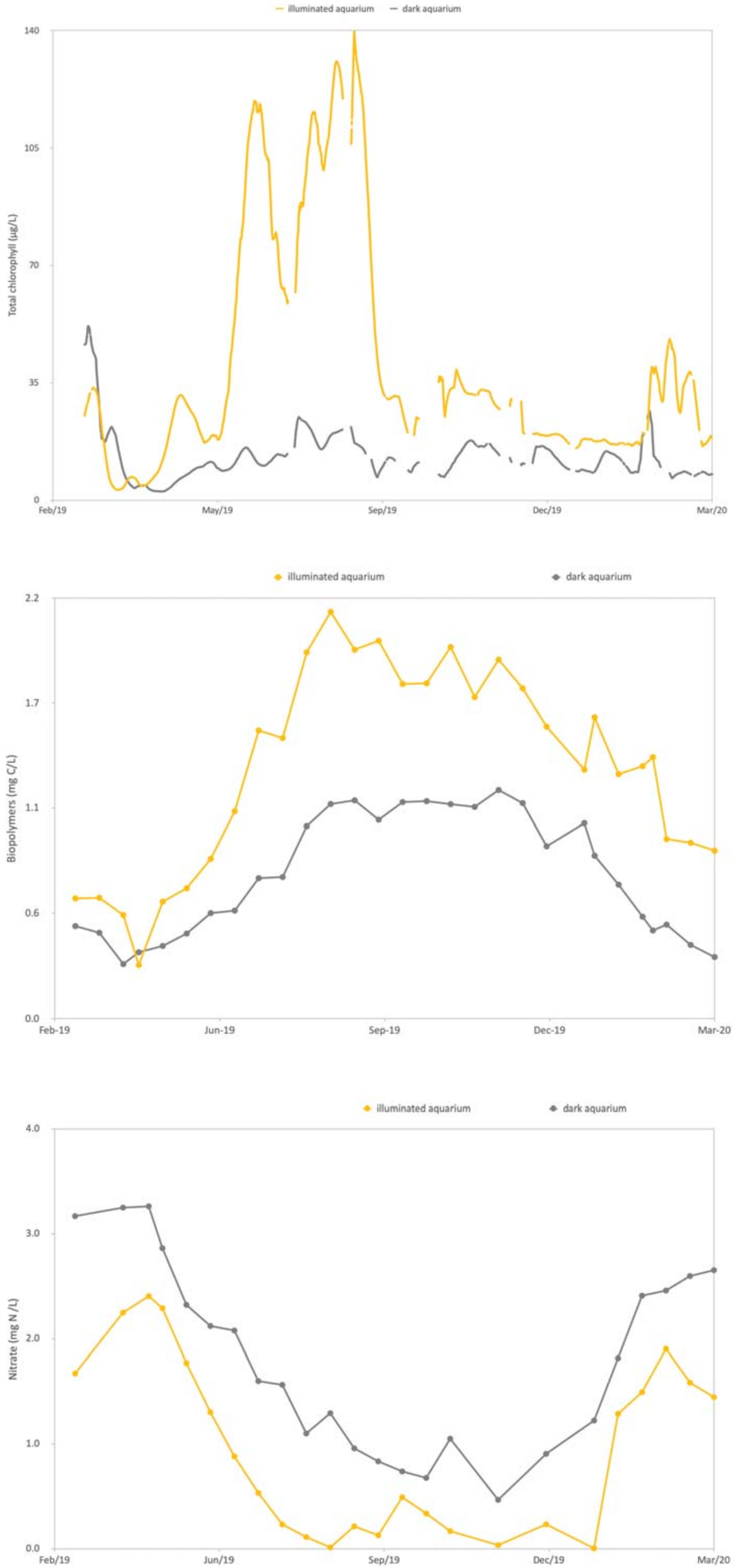

Figure 2 Comparison of total chlorophyll, biopolymers, and nitrate concentrations in the effluents of the illuminated aquarium and the dark aquarium over the duration of the experiment

FINDINGS: POSITIVE AND NEGATIVE IMPACTS ON WATER QUALITY

The study showed as hypothesized that reducing light input in the water reduces significantly algal growth, with significantly lower algal concentrations in the black aquarium than in the illuminated aquarium (Figure 2). This resulted in lower dissolved organic carbon (DOC) concentrations mainly caused by a lower biopolymer production by algae in the dark aquarium. Reducing biopolymers in water could be beneficial for the water treatment process, as biopolymers are responsible for treatment challenges such as membrane fouling. However, the lower light input also resulted in higher inorganic matter concentrations such as phosphate, nitrate, bicarbonate or silicate, as a result of lower consumption by algae. The removal of such nutrients by the water treatment is essential as inorganic nutrients may contribute to bacterial regrowth in the drinking water distribution system and lead to biological instability. The study showed therefore that reduced light input caused by floating solar panels may have concomitant positive and negative impact on raw water quality used for drinking water production.

CONCLUSION: NEED FOR FULL-SCALE WATER QUALITY MONITORING UPON INSTALLATION

At this stage however, it is too early to conclude whether the measured effects in the controlled aquarium test will be significant at full-scale under real conditions. The impact of reduced light input by floating solar panels at PWN's treatment facility may be limited by the design of the panels, organised in small islands equally distributed over the surface, therefore avoiding a large area being fully covered (Figure 3). However, the mechanisms involved are the result of a complex ecological system in the water reservoir, where algae consume nutrients and are in turn part of a larger food chain, which are difficult to predict. Comparison of relative concentrations of different algal groups in the raw water, full-scale reservoir, illuminated and dark aquaria showed that the environmental conditions strongly influence the ecology of water. Algal species and concentrations also strongly vary along the year, as illustrated in Figure 1. Other impacts of solar panels such as wind mixing and localised growth also need to be considered. PWN will be carefully monitoring water quality before and after installation of the solar panels to detect any deviation in water quality. The study is a prelude to larger-scale implementation of solar panels to reduce treatment plant energy consumption costs without adverse impact on surface water quality for drinking water production. WWA

Figure 3: Floating solar panel in the form of an island