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MONITORING THE IMPACTS OF FLOATING STRUCTURES ON THE WATER QUALITY AND ECOLOGY USING AN UNDERWATER DRONE

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ABSTRACT

Urban delta areas require innovative and adaptive urban developments to face problems related with land scarcity and impacts of climate change and flooding. Floating structures offer the flexibility and multi-functionality required to efficiently face these challenges and demands. The impact of these structures on the environment, however, is currently unknown and research on this topic is often disregarded. This knowledge gap creates a difficulty for water authorities and municipalities to create a policy framework, and to regulate and facilitate the development of new projects.

Monitoring the effects of floating structures on water quality and ecology has been difficult until now because of the poor accessibility of the water body underneath the structures. In this work, a remote controlled underwater drone equipped with water quality sensors and a video camera was used to monitor dissolved oxygen near and under floating structures. The collected data showed that most water quality parameters remain at acceptable levels, indicating that the current small scale floating structures do not have a significant influence on water quality. The underwater footage revealed the existence of a dynamic and diverse aquatic habitat in the vicinity of these structures, showing that floating structures can have a positive effect on the aquatic environment. Future floating structures projects therefore should be encouraged to proceed.

Keywords: underwater drone, water quality, dissolved oxygen, floating urbanization, climate change, environmental impact

1. INTRODUCTION

Urban delta areas are facing problems related to land scarcity and are impacted by climate change and flooding. To meet the current demands, innovative and adaptive urban developments are necessary (de Graaf, 2009), especially for low-lying areas, which are particularly susceptible to flooding. Floating structures are good examples of the flexibility and multifunctionality required to efficiently face the current challenges for delta cities (de Graaf, 2013). They offer flood proof buildings, possibilities for water storage and opportunities for sustainable food and energy production (Roeffen et al., 2013).

However, before increasing the number and scale of this kind of floating projects, it’s important to understand how these projects may affect the environment. Their possible positive or negative impacts are currently largely unknown and are often disregarded as a priority for research. Although there have been some studies on water quality effects of floating structures (e.g. Boogaard & Graaf, 2014, de Buck, et al., 2014; Kitazawa, et al., 2010), the employed research methods are usually ineffective and do not or only partly include the water body underneath the structures, which usually is difficult to access (small free board between the floating platform and the ground). Therefore, innovative research methods and further measurements and studies are necessary.

This knowledge gap complicates the task of water authorities and municipalities to create a policy framework, in order to regulate and facilitate the development of new floating projects (de Graaf, et al., 2014). This frequently results in the hindering or delay of this kind of projects. Our study therefore aims at gathering more information about the positive and negative impacts of floating structures, and tries to quantify how much the water quality parameters can change due to the presence of these structures. The outcomes of this research could also contribute to pinpoint guidelines and recommendations to improve the sustainability and viability of future floating structure projects.

2. METHODOLOGY

Monitoring water quality under floating structures has been difficult until now because of the poor accessibility of the water body underneath the structures. In this research project, a remote controlled underwater drone (Thunder Tiger Neptune SB-1) equipped with water quality sensors and a video camera (Figure 1), was used to perform dissolved oxygen measurements under and around floating buildings/platforms (Boogard & Graaf, 2014). The drone monitored several water quality parameters, such as pressure (depth), temperature, conductivity, nitrate, ammonium, dissolved oxygen and turbidity. In addition to the data from the sensors, the underwater drone also collected footage of aquatic life, which were used to assess the ecology and habitat under in the vicinity of the floating structures. Data was collected from several different locations throughout The Netherlands, from July until October 2014.

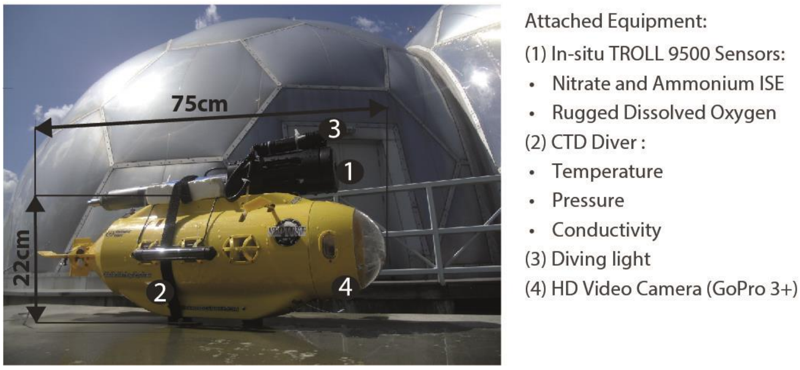

Figure 1. The underwater drone with the attached equipment (near the Floating Pavilion, Rotterdam).

During the measurements, the underwater drone is guided to under the floating structures, where it collects water quality data with sensors. As a control, data is also collected from open water zones of the same water body. To ensure that the blockage caused by the floating body has no influence on these measurements, open water measurements are taken at a distance of at least 8 m from the floating platform. Figure 2 illustrates these procedures and measuring locations. Unfortunately, because GPS tracking is not easy/possible underwater and other positioning and tracking options (Liu & Sun, 2011; Leonard, et al., 1998) were not available, knowing the exact position of the drone under the floating structures was difficult. Therefore, the tracking of the drone was mostly based on video recordings (dry and underwater footage) and visual information stored in a logbook. The depth is recorded with a pressure sensor (CTD diver).

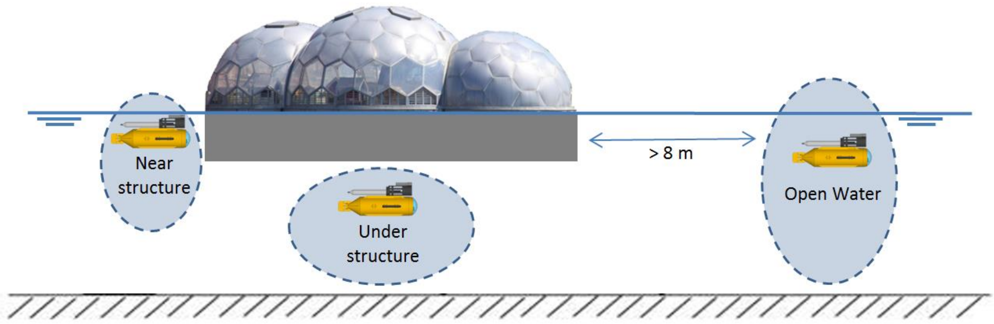

Figure 2. Schematization of the zones of collection of data (Floating Pavilion, Rotterdam).

3. RESULTS AND DISCUSSION

3.1 Water quality

The results in this paper focus on the analysis of dissolved oxygen. It is one of the most affected parameters by the presence of floating structures, due to the coverage of the water surface, and consequent influence on the air-water interactions (Foka, 2014; Hartwich, 2014). Water quality assessment is a subject of high complexity, as the parameters vary not only temporally (e.g. daily, seasonal) and spatially, but also with water depth and temperature. In order to analyze how the water quality parameters vary under floating structures, the measured data was divided in depth ranges and then the averages for each depth were computed (Figure 3). This allowed evaluation and comparison of results from different depths and zones, and to quantify the effects that the floating body may cause. Figure 3 shows that the dissolved oxygen is always slightly lower under the floating structure, than in open water, at the same depth.

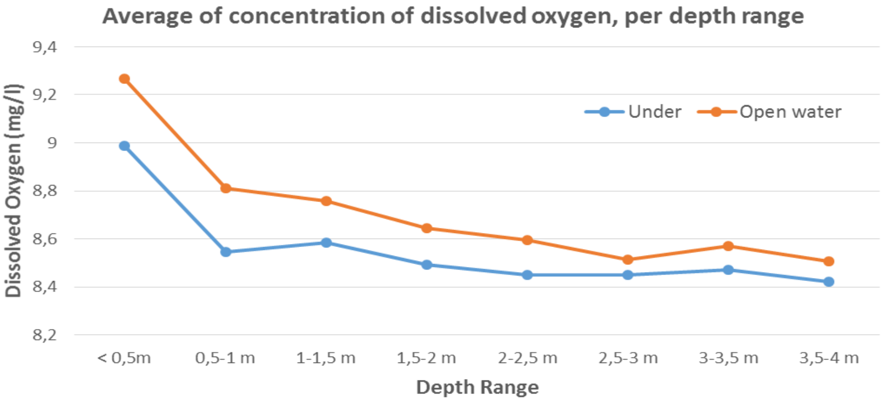

Figure 3. Comparison between the averages of the concentration of dissolved oxygen under/near floating structures and in open water, per depth range (Floating Pavilion, Rotterdam, 13 August 2014).

The analysis of the minimum oxygen concentrations detected under floating constructions is also of great interest because it allows to see if acceptable oxygen levels for aquatic life are maintained at all times. Figure 4 represents these minimum values of dissolved oxygen, both in open water and under the floating structures at different locations. It can be observed that, although reaching lower values under the structure than in open water (8 m away from structure), the concentration of dissolved oxygen stays within the range of 6 to 9 mg/L for most locations. This range is higher than the usual reference dissolved oxygen concentration value that safeguards normal aquatic life in ponds and water bodies of around 4.5 mg/L (e.g. Alaska, 1979; Alberta, 1977). However, there were two exceptions: Amsterdam (Chinese Restaurant), where the minimum dissolved oxygen concentration in open water was already low and Delft (Harnaschpolder). For the latter, the reason why the dissolved oxygen concentrations reached such a low value is quite unclear, but considering the small space available between the house and the bottom, it is likely that it was filled with clayish sludge, thus creating anoxic conditions.

Figure 4. Comparison between the minimum concentrations of dissolved oxygen detected under/near floating structures and in open water, per location.

3.2 Underwater footage

In addition to the dissolved oxygen data from the sensor, a high definition video camera was used to collect underwater footage (Figure 5). However, in some locations the water was turbid, which resulted in poor video quality observations or even made it impossible to see more than a few centimeters ahead of the camera. When the water was clear enough, it was possible to identify several fish species swimming under and near these floating structures, along with many other organisms attached to the structures (e.g. dreissenid mussels). The floating structures seem also to be attractive for zooplankton and Mysidae (Neomyses spp). The presence of these species of fish and other aquatic life forms interacting with these structures may also be regarded as good water quality indicator. The underwater footage gave some insight into what happens under floating structures. It was observed that a whole new habitat is created, which was previously not present.

Figure 5. Examples of underwater footage with aquatic life under floating houses in Maasbommel and Lelystad (NL).

4. CONCLUSIONS

Based on the results from this study, the existing current small scale floating structures do not have a significant influence on water quality. The detected differences in the concentration of the measured water quality parameters (e.g. dissolved oxygen) between open water and under/near the structures parameters are low, and most parameters remain at acceptable levels. Regarding the ecology, underwater footage from the video camera revealed a multitude of aquatic organisms attached to these structures (e.g. mussels) and fish swimming underneath them. This shows that, if designed correctly, floating constructions can stimulate aquatic life and biodiversity in the surroundings of these structures, by creating new habitats and by providing shelter for smaller and juvenile fish, thus having a positive impact in the environment.

Moreover, it was understood that underwater drones show a high potential as water quality monitoring tools, considering that they can easily reach limited-access zones to collect data, that otherwise would be expensive or even unsafe to perform (e.g. human divers). However, there are still some challenges to surpass in future research studies, such as the difficulty of knowing the exact location of the drone, which could possibly be solved if more advanced equipment was available.

As a final remark, data and videos from several locations around The Netherlands are available in an online tool (www.climatescan.nl). This website aims at promoting knowledge exchange among stakeholders, and to make these insights into environmental impact of floating solutions accessible. The information and finding from this work are of great value for many (mega) cities (such as London, New York, Manila), where plans are made to build floating structures in the near future.

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