AMSTERDAM INTERNATIONAL WATER WEEK

Innovative dynamic water quality and ecology monitoring to assess about floating urbanization environmental impacts and opportunities.

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Abstract: Floating urban solutions offer flexibility and resilience that can contribute for improved and sustainable cities. In order to better understand and analyse how floating structures impact their surrounding environment, a remote-controlled underwater drone was used to collect dynamic water quality and ecology data in the vicinity of floating structures. The drone was equipped with multi-parameter water quality sensors and with HD video cameras, which allowed to observe underwater aquatic life. Several different locations around The Netherlands were visited and studied. Some interesting relations between the characteristics of the structures and patterns in the differences in average dissolved oxygen concentrations between open water and zones near/under floating structures were accomplished (e.g. material of the structures, available space under the structures). Results indicate that the impact of current small scale projects are not significant regarding dissolved oxygen concentrations, and that this type of floating projects can even have a positive impact on ecology.

Keywords: underwater drones; floating urbanization, environmental impacts, water quality monitoring

Introduction

Sustainable and resilient urban areas require innovative and adaptive urban developments to face problems related with land scarcity and also with impacts of climate change and flooding. Floating structures offer the flexibility and multi-functionality required to efficiently face these challenges and demands (de Graaf, 2009).

The design of integrated and sustainable symbiosis between cities on land and floating developments on water can contribute, for example, to close nutrient and waste cycles and to provide ecological services to coastal cities. Deltasync's BlueRevolution concept (Figure 1; http://blue21.org/) is an example of such design, where waste nutrients and CO2 can be used/recycled for the production of food and biofuel in floating cities, through floating algae systems (Roeffen et al, 2013).

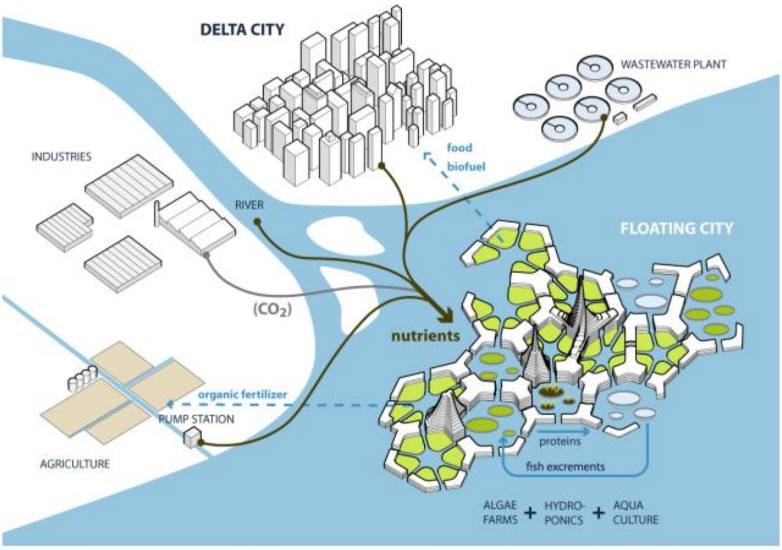

Figure 1 Representation of the BlueRevolution concept, an innovative and sustainable floating design idealized by Deltasync. (Roeffen et al, 2013; http://blue21.org/).

However, the environmental impact of these structures, either negative or positive, is still unknown, and additional research is necessary. 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 (Boogaard and de Graaf, 2014; de Lima et al., 2015). Unfounded concerns of harming the environment by introducing this kind of structures on the water frequently hinders the implementation of innovative new floating developments, which, under certain circumstances, may even be the most adequate, cost-efficient, and environmentally friendly solutions.

The introduction of floating buildings and platforms changes the aquatic environment by covering the water surface, and thus influence important factors such as the penetration of light, or the air-water interactions, which play an important role in multiple biological, chemical and physical processes. Figure 2 is a representation of some changes in the aquatic system that floating structures may induce.

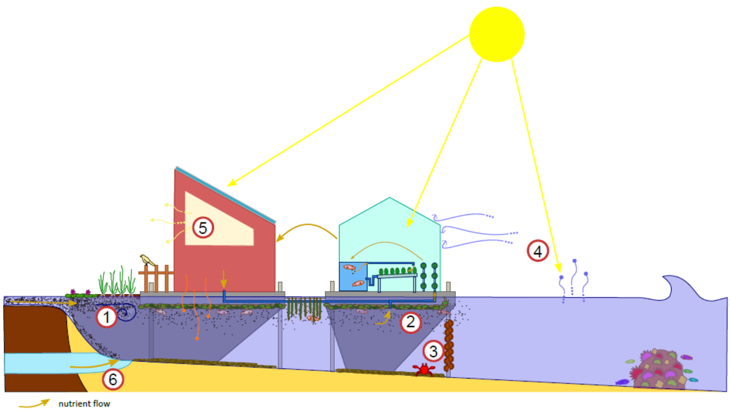

Figure 2 Impacts of floating structures in the water system. In the picture: 1. Change of water flow/sediment deposition; 2. Anaerobic conditions; 3. Invasive species; 4. Ecological trap; 5. Local climate change; 6. Emissions (adapted from Hartwich, 2014).

Until now, only a few studies tried to understand how these structures interact with the surrounding environment (de Buck et al., 2014, Foka, 2014, Kitazawa et al., 2010, Hartwich, 2014). However, the research methods used often disregard the water underneath the structures, which is difficult to access. Therefore, the objective of this work is to further research this topic by collecting and examining water quality and ecology data including the area underneath these structures, by collecting data in an innovative and dynamic way (using underwater drones), and to understand if structures with different materials and characteristics result in differences in observed water quality parameters and/or ecology.

Material and Methods

Between July 2014 and October 2014, dynamic water quality measurements and ecological scans were performed in several locations with floating structures in The Netherlands (15 in total, see Figure 3). The locations provided a wide range of water system types and conditions, and also included a wide variety of floating structures characteristics.

Figure 3 Map with the locations visited between August 2014 - October 2014, for water quality and ecology data collection campaigns.

The data was collected using an underwater drone equipped with powerful multi-parameter water quality probe (In-situ Multi-Parameter TROLL 9500) and with HD video cameras (Figure 4). The installed water quality sensors allowed to measure parameters such as dissolved oxygen, nitrate, ammonium and temperature (the present work focuses on dissolved oxygen concentrations). For each location, data was collected both near and under the structures, but also in open water (unaffected by the influence of floating structures), which was used as a control. In addition, the underwater video images provided insight into the aquatic environment (e.g. vegetation, presence of fish) nearby these structures.

Figure 4 Underwater drone equipped with water quality sensors (multi-parameter probe on top and CTD on the side) and with HD video cameras (at the front).

Results and Discussion

Due to the high variety of the several locations studied (different water systems characteristics and conditions), it was not possible to directly compare data from the different locations. Nevertheless, the detected differences in concentrations of water quality parameters (between measurements in open water and underneath structures) were possible to interrelate with some physical characteristics of the structures. Figure 5 shows that the dissolved oxygen is lower in locations where there is more space under the structures, which, in the locations visited, was directly connected with the water movement underneath the structures. This is probably related with the higher renewal rate of the water in these cases (water stays less time under structures), which seems to be one the more relevant processes that influences how floating structures affect water quality.

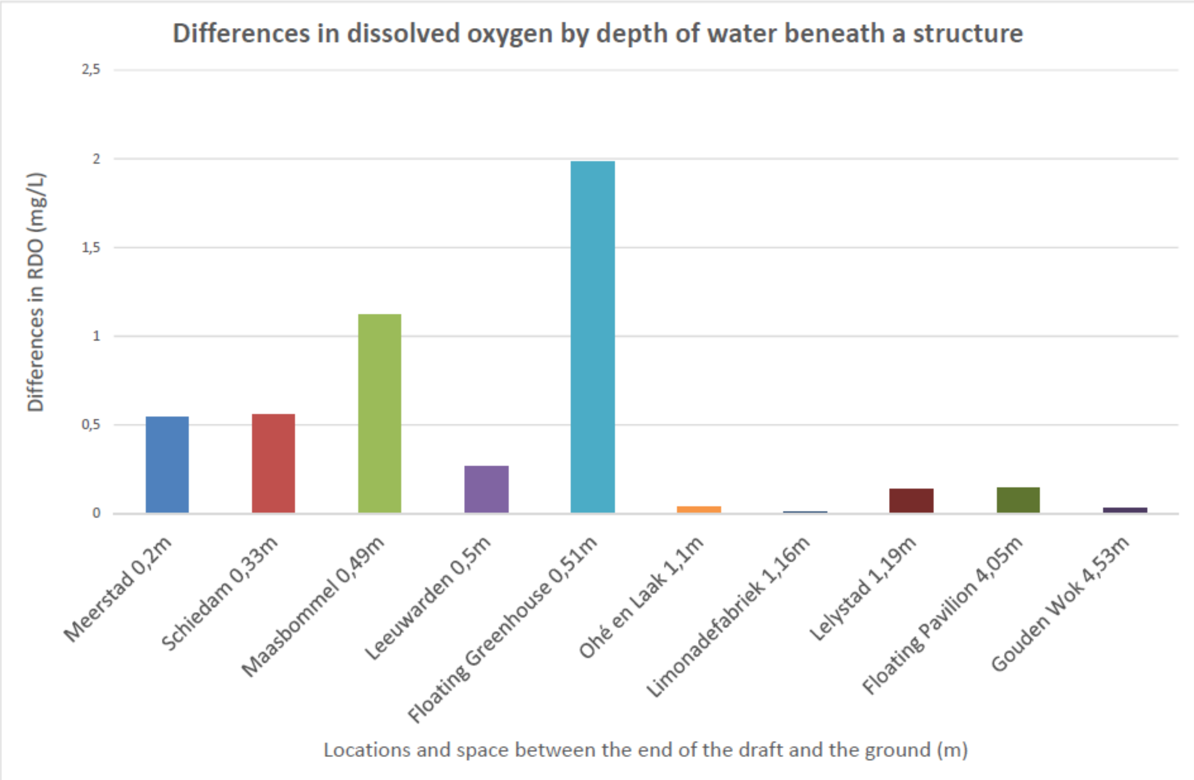

Figure 5 Representation of the differences between the averages of dissolved oxygen concentrations measured in open water (>8m away from the structure), and near/under the structures, in several different locations. The locations are ordered by the available space (free board) between the house and the ground.

From the underwater images, it was possible to detect some variability on the appearance of floating structures. This could be associated with the material of the foundation of floating structures. For example, in metal structures, the quantity of vegetation and organisms (e.g. mussels) attached to the structures was significantly lower (Figure 6).

Figure 6 Differences in the vegetation attached to floating structures: polyester (left) and steel (right).

Additionally, mussels were found attached not only to older structures (e.g. floating holiday houses in Roermond, built over 15 years ago), but also in recent structures (e.g. floating homes in Ohe en Laak, project completed in 2012). In some locations it was also possible to identify the presence of fish (Figure 7), which also provides some information about water quality and eco-system health (Kroes, 2015). However, the presence of high water turbidity (low transparency) in several of the case studies was a barrier to better and more detailed results.

Figure 7 Underwater images of aquatic life in Groningen (left), Lelystad (center) and mussels in Schiedam (right).

The collected data and videos from several locations around The Netherlands are available in an online tool (www.climatescan.nl), which is constantly being updated with new water related data and information (not exclusively about this study). This website aims at promoting knowledge transfer among stakeholders, and to help gaining insight on the environmental impact of floating solutions.

Conclusions

The water quality data collected in this measurement campaign (Foka et al, 2015, de Lima et al., 2015) did not reveal alarming concentration values of the measured parameters, in any of the several measured locations. Nevertheless, slight differences in concentrations were detected between open water and under/near the structure. It was possible to establish some relations between these differences and the characteristics of the water body. The clearest relation was with the space available underneath the different structures, and their probable connection with water movement and currents. For future research, flow velocity underneath the structures should be also taken into account.

Regarding the ecological data from underwater images, this study also showed that different materials have an influence on the type and amount of vegetation on the surface of the structures (underwater), and confirmed that underwater life can be lively in the vicinity of these structures, and not necessarily affected in a negative way by them. The presence of these interactions with the aquatic life, and the observed diverse and active new habitat, indicates that floating structures may even have a positive impact on ecology (without floating structures vegetation and organisms wouldn’t have a surface to get attached to, nor would fish be able to use the structures as opportunities for shelter).

Floating structures can therefore be an opportunity for possible “building with nature” designs, and thus being designed together with ecological measures. Further research is necessary on how to design new floating developments in a way that fulfils their environmental-friendly potential and thus contribute to increase bio-diversity. The knowledge of the best design configurations and configurations to be avoided is of high interest for new projects and important to take into account in future plans for floating urban developments, especially for the possible upcoming large-scale-projects in mega delta cities such as Manila, London, or Jakarta.

Final remarks

In addition to the insight into the effects of floating structures on water quality, this research also delivered good feedback regarding the uses of underwater drones equipped with water quality sensors and video cameras as environmental monitoring tools. This setup allowed us to easily access the zones near and under floating structures to collect the data. Some of the locations only had a small layer of water available between the floating structure and the ground (sometimes less than 50 cm), which would have been difficult and challenging to access and monitor using other methods (expensive, troublesome or even unsafe).

It was understood that drones are suitable for use for water quality measurements, as they are capable of performing fast water quality monitoring tasks that otherwise would be rather complicated and less efficient. INDYMO (www.indymo.nl), in collaboration with educational/research institutions and water authorities, is currently exploring the potential of this versatile tool/technique in several applications in the water sector in The Netherlands.

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