Announcement of a master thesis

For the topic:

Plastic clogging of inlet grates and hydraulic capacity reduction

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Background

Inlet grates are designed to safely evacuate urban runoff during rainfall events (Figure 1). These small elements within the urban water infrastructure are the entry door to the sewer system. If these elements are designed with insufficient discharge capacity, these may act as a bottleneck in the system and water will be stored in the streets, potentially leading to urban flooding. Plastics, ubiquitous in cities, may end up in the floor, being then transported into the inlet grates by the urban runoff during rainfall events (Figure 2).

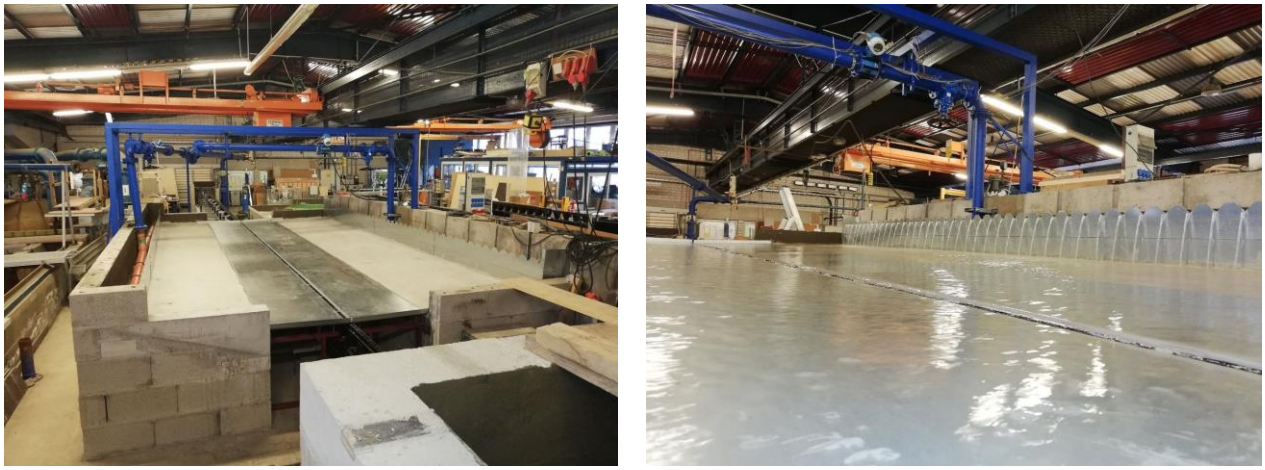

Figure 1. Physical test station of longitudinal inlet grates at the Theodor Rehbock's Hydraulics Laboratory. Left: overview of the model. Right: simulation of a rain event (IWG, 2021).

Problem statement

Daily activities involve usage of a wide range of plastic objects. From disposable plastics, single use items, to other long-life, perennial things. Accidentally, some can escape solid waste management and remain in the urban environment. Bulk generation may also occur during open air concerts or festivals. These plastics are usually light and can easily be carried away by runoff, which seeks a route towards the drainage system. In between, grates may act as bottleneck filters where all the debris

accumulates (Honingh et al., 2020), thus reducing the effective area available for the water flow. Visual inspection of Figure 2 readily reveals that a significant portion of the inlet area is covered by litter.

Figure 2. Sewer grate and plastic debris partially clogging a significant area of the inlet section (July 2021, German flooding).

Research objectives

During this research, the student is expected to tackle several questions raised from the aforementioned observations. Among others:

1. Which are the most common plastic elements found in the urban environment that may eventually be found in sewer grates?

2. How to scale plastic debris problems in hydraulic laboratory models?

3. How to properly characterize different plastic debris elements from a hydraulics standpoint?

4. How to extend the results obtained in laboratory to real-world applications?

5. Which plastics clog more harmfully the urban inlet grates?

6. Which is the subsequent inlet grate discharge capacity reduction depending on the number and class of plastics clogging it?

7. What are the mechanisms impeding the runoff into the inlet grates for the most common types of plastics?

Methodology

The MSc candidate will be working with a 1:1 scale physical model of inlet grates (Figure 1) in the Theodor Rehbock's Hydraulics Laboratory (KIT, IWG). The student will make use of the hydraulic facilities as well as appropriate measurement equipment while receiving the necessary support from the laboratory (technical and scientific) staff.

A first stage of this research will consist on urban landscape inspection in the Karlsruhe area, enabling an inventory of plastics susceptible to clog the sewer grates. This can also build upon

available literature or crowd platforms such as OpenLitterMap (*https://openlittermap.com)*. Clean versions of these plastics will be acquired, to be used in a second stage for physical modelling. The samples conveniently characterized in laboratory. Afterwards, a large number of samples will be released under controlled conditions while monitoring the performance of the inlet grates model, which is to be compared to ideal (unclogged) performance.

The student is expected to both provide insightful discussion on clogging mechanisms for different classes of plastics as well as develop hydraulic calculations that enable hydraulic engineering design of inlet grates under the threat of plastic clogging. The candidate is expected to be familiar with discharge capacity equations and dimensional analysis. MS EXCEL proficiency is recommended and programming skills (MATLAB/Python) may prove valuable.

References

Honingh, D., van Emmerik, T., Uijttewaal, W., Kardhana, H., Hoes, O., & van de Giesen, N. (2020). Urban River Water Level Increase Through Plastic Waste Accumulation at a Rack Structure. *Frontiers in Earth Science*, *8*. https://doi.org/10.3389/feart.2020.00028

Kemper, S., & Schlenkhoff, A. (2019). Experimental study on the hydraulic capacity of grate inlets with supercritical surface flow conditions. *Water Science and Technology*, *79*(9), 1717-1726.