Institute for Water and Environment
Hydraulic Engineering and Water Resources Management
Prof. Dr. Mário Franca

BSc thesis/study project

on the subject

Characterizing the hydrodynamics of real river plastic pollution

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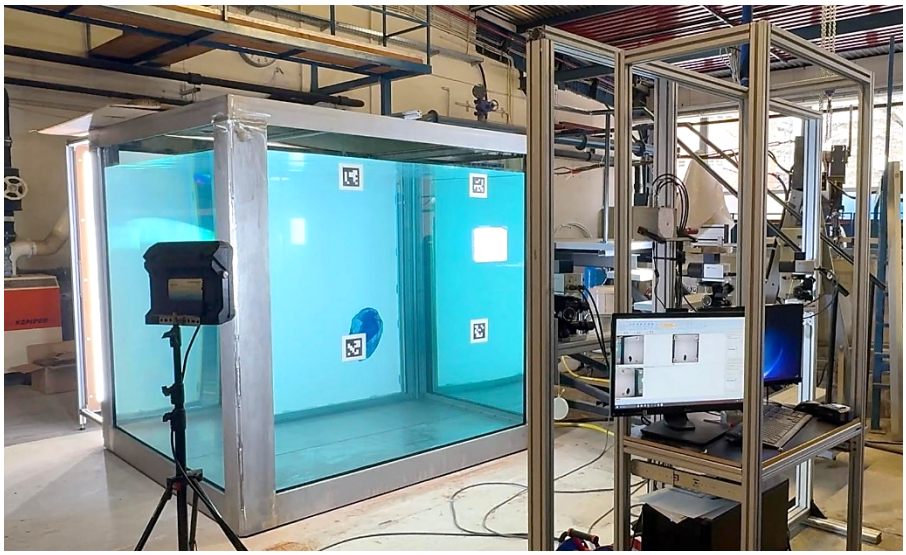

Background and motivation

The presence of plastic in rivers poses significant risks to the health of fluvial ecosystems and the organisms that depend on them. As a result, there is growing interest within the field of ecohydraulics in studying the transport and fate of plastic in river systems.

In recent years, several studies (Goral et al. 2023; Russell et al. 2023; Waldschläger et al. 2022) have suggested that plastic transport in rivers could be considered a special case of sediment transport, for which a well-established theoretical framework already exists. At the Institute for Water and Environment at the Karlsruhe Institute of Technology, we are currently conducting two research projects focused on this topic (DFG 2024; Lofty, Valero and Franca 2025).

Plastic litter can be transported in rivers through various modes (Lofty, Valero, Wilson et al. 2023; Lofty, Valero, Moreno-Rodenas et al. 2024; Valero et al. 2022), depending on the plastic's physical

properties and the river's hydrodynamic conditions: contact load, a form of bedload transport in which litter slides or rolls along the riverbed in almost permanent contact with it; saltation, another bedload transport mode characterized by litter particles intermittently jumping at a mean height of several particle diameters; suspended load, where litter moves within the water column with negligible contact with the bed; and surface transport, which occurs when litter travels in contact with the free surface of the water.

Just as the Reynolds number is used to distinguish between laminar and turbulent flow regimes, the Rouse number is employed to determine the likely transport mode of a particle, including plastic litter. The Rouse number (β) is defined as:

$$\beta = \frac{w}{\kappa u_*}$$

where w is the settling velocity (if positively buoyant, i.e. the particle sinks) or the rising velocity (if negatively buoyant, i.e. the particle rises) of the litter, and u_* is the flow shear velocity. As seen from Eq. 1, the settling or rising velocity of a plastic particle is a critical parameter in understanding the transport of plastic litter in rivers.

Accurate modelling of real and pristine river plastic transport requires a thorough description of the settling or rising velocity of plastic particles and therefore must be examined experimentally.
Scope of the work

The study is foreseen to include the following activities:

- Literature Review
    - A comprehensive review of existing research on plastic transport in riverine environments.
- Experiments
    - Experiments were conducted in a quiescent water tank (dimensions: 2 × 0.98 × 0.57 m3) at the Theodor Rehbock Flussbaulaboratorium. Plastic litter collected from the river will be released in the tank to either sink or rise. Their trajectories will be recorded using three-dimensional particle tracking velocimetry with an in-house custom plastic tracking code (3D-PTV).
- Data Analysis
    - The collected data will be analysed to explore the relationship between the settling/rising velocity (w) and key controlling parameters such as litter size, shape, density, and deformability.
- Discussion of the Results
    - The empirical relationships derived for plastic particles will be compared with existing models from sediment transport theory. Similarities and differences will be highlighted, and the physical basis for any observed deviations will be discussed, as well as the consequences for engineering models of plastic transport in rivers.

Redaction of the Master Thesis

The writing of the Master thesis will follow the guidelines provided by the Institute for Water and Environment (IWU-WB) at KIT. The official guidelines and templates are available online at IWU-WB Education – Thesis Guidelines.

References

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