Institute for Water and Environment (IWU), Karlsruhe Institute of Technology

Hydraulic Engineering and Water Resources Management

Prof. Dr. Mário Franca

Master thesis

on the subject

Settling and rising dynamics of plastic pollution in rivers

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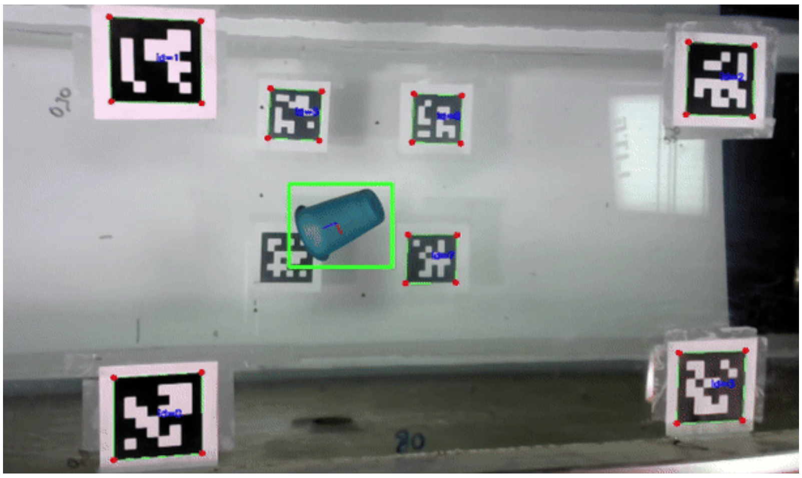

Fig.1 Tracking of a plastic cup in the settling tank.

Background / 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. Recently , 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 exists. At IWU-KIT, we are currently conducting two research projects focused on this topic (DFG, 2024; Lofty et al., 2025). Plastic litter can be transported in rivers through various modes (Lofty et al., 2023, 2024; Valero et al., 2022), depending on plastic's physical properties and the river's hydrodynamic conditions:

- Contact load: Bedload transport in which litter slides or rolls along the riverbed in almost permanent contact with it.
- Saltation: Bedload transport characterized by litter particles intermittently jumping at a mean height of several particle diameters.
- Suspended load: Litter that moves within the water column with negligible contact with the bed.
- Surface transport: Litter that 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:

$$\beta = \frac{1}{0.41} \frac{w}{u_*} \qquad \text{(Eq.1)}$$

Where w is the settling (if positively buoyant, i.e. they sink) or rising (if negatively buoyant, i.e. they rise) velocity 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 plastic transport in rivers 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 rivers.
- **Experiments:** Experiments conducted in a quiescent water tank (dimensions: 2 × 0.98 × 0.57 m^3) at the Theodor Rehbock Flussbaulaboratorium. Plastic litter of various sizes and shapes—selected to reflect the most common shaped of litter items found in river—will be released in the tank to sink or rise. Their trajectories will be recorded using three-dimensional particle tracking velocimetry using a custom plastic tracking code (3D-PTV).
- **Data Analysis:** Collected data will be analysed to explore the relationship between the settling/rising velocity and controlling parameters (e.g. 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:** Guidelines for MSc thesis at IWU-WB can be accessed here.

Remarks

The thesis will be developed in collaboration with the Imperial College London (Dr. Daniel Valero). The project requires an affinity for evaluation/execution hydraulic experiments, basic programming and data analysis. General scripting skills and Matlab/python programming are helpful.

References list

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