Karlsruher Institut für Technologie
Institut für Wasser und Umwelt
Wasserbau und Wasserwirtschaft
Prof. Dr. Mário J. Franca

Study project / Master thesis

on the subject

Plastic transport in rivers as bedload

Student:	Name Surname (Student ID: xxx)
Timeframe:	XX.XX.202X - XX.XX.202X
Supervisory team:	Prof. Dr. Mário J. Franca (IWU), Dr. Daniel Rebai (IWU), Dr. James Lofty (IWU), Dr. Frank Seidel (IWU)
External supervisor:	Daniel Valero (ICmperial College London)
Contact:	Dr. Daniel Rebai (IWU) daniel.rebai@kit.edu

Figure 1 Litter considered in this study.

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 et al. 2025).

The purpose of this thesis is to study the transport of plastic in rivers by means of flume experiments. Litter will be released into the flume, and its position will be tracked using particle tracking velocimetry. Different hydrodynamic conditions will be tested by varying the flow rate in the flume and, consequently, the Shields parameter, defined as

$$\theta = \frac{\tau}{(\rho_s - \rho)gd} \tag{1}$$

where τ is the bed shear stress (often expressed as $\tau = \rho u_*^2$, with u_* the shear velocity), ρ_s is the density of the particles, ρ is the fluid density, g is the gravitational acceleration, and d is the characteristic particle diameter.

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 will be conducted in a laboratory flume (23 m long, 0.7 m high, and 0.5 m wide) at the Theodor Rehbock Flussbaulaboratorium. Plastic litter will be released in the flume. Their trajectories will be recorded using three-dimensional particle tracking velocimetry with a custom plastic tracking code (3D-PTV).
- **Data Analysis**
  The collected data will be analysed to explore the relationship between the plastic velocity (u, v, w) and key controlling parameters such as the Shields number.
- **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.

Karlsruhe, XX.XX.202X
Prof. Dr. Mário J. Franca

References

DFG (2024). *InMoBed: Mobilization and Transport of Plastic*. Research project.

Goral, K. D., H. G. Guler, B. E. Larsen, S. Carstensen, E. D. Christensen, N. B. Kerpen, T. Schlurmann and D. R. Fuhrman (2023). “Shields Diagram and the Incipient Motion of Microplastic Particles”. In: *Environmental Science & Technology* 57.25, pp. 9362–9375. DOI: 10.1021/acs.est.3c02027.

Lofty, J., D. Valero and M. Franca (2025). *Determining the Settling and Rising Velocities of the Top Polluting Macroplastics in Rivers*. EGU preprint. DOI: 10.5194/egusphere-egu25-3136.

Russell, C. E., F. Pohl and R. Fernández (2023). *Plastic as a Sediment – A Universal and Objective Practical Solution to Growing Ambiguity in Plastic Litter Classification Schemes*. DOI: 10.31223/X5FH3R.

Waldschläger, K., M. Z. M. Brückner, B. Carney Almroth, C. R. Hackney, T. M. Adyel, O. S. Alimi, S. L. Belontz, W. Cowger, D. Doyle, A. Gray, I. Kane, M. Kooi, M. Kramer, S. Lechthaler, L. Michie, T. Nordam, F. Pohl, C. Russell, A. Thit and N. Wu (2022). “Learning from Natural Sediments to Tackle Microplastics Challenges: A Multidisciplinary Perspective”. In: *Earth-Science Reviews* 228, p. 104021. DOI: 10.1016/j.earscirev.2022.104021.