Experimental and numerical methods in investigations of sustainable deep scours as fish habitat

Christin Kannen[1]*, Frank Seidel[1], Franz Nestmann[1]

1 Karlsruhe Institute of Technology, Karlsruhe, Germany

*Correspondence YP: Christin.Kannen@kit.edu

Abstract Former regulative measures on water bodies have highly affected structural diversity and thus the habitat quality for fish. In a 3-year research project, funded by the Fisheries Department of the state of Baden-Württemberg, hydraulics and morphodynamics of deep watercourses and scours will be investigated. The background and objectives of the project are explained and the scouring mechanisms are investigated with three different methods: flume experiments, numerical simulations and field studies.

Keywords: scour, morphodynamics, sediment transport, fish habitat, ecohydraulics

Scouring processes

Leading processes of the development of scouring are due to higher flow velocities, higher turbulence, secondary currents and combinations of the latter (Zanke, 1982). Scouring can be divided into Clear-water scour for $U_o/U_c < 1$ and Live-bed scour for $U_o/U_c > 1$ (e.g. Melville 2008). The influencing factors on scour depth are (e.g. Breusers, (1991), Melville (2008) or Sheppard (2004)):

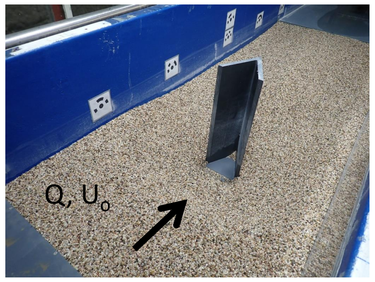
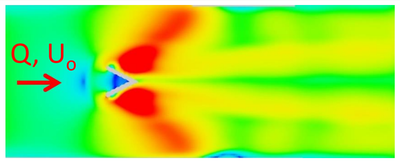
- Parameters of fluid: fluid density ρ, kinematic viscosity v
- Parameters of flow: mean flow velocity U_o, depth of approaching flow h, gravity g, overflow depth $h_{overflow}$
- Parameter of bed material: geometric mean diameter d_{50}, geometric standard deviation σ_g, density of the sediment ρ_s, mean critical velocity U_c
- Geometry of the structure (shape, dimensions, surface)
- Time-dependent processes

Methods

An overview of the methods that will be applied is given in Table 1. The hydraulic and morphodynamic boundary conditions are based on local aspects of the state of Baden-Württemberg.

- Hydraulic conditions: according to exemplary sites Schwarzenberg (river Murg) and Criesbach (river Kocher)
- Discharges: 2 year flood, low flow
- Predominantly disturbed bedload balance in the rivers of Baden-Württemberg → clear-water scour conditions
- Flume experiments: scale 1:25, mean diameter of the sediment (d_{50}) = 3 mm
- Velocity measurements: LDA-system
- Bed topography measurement: Structure from Motion
- Application of a hydrodynamic and later a hydro-morphological numerical 3D approach
- Analysis of different case studies in the state of Baden-Württemberg.

Table 1: Overview of application of model types.

Physical Model	Numerical Model	Field Study
Movable bed experiments 	Simulations with flat, rigid bed Simulations with scoured, rigid bed Simulations with movable bed with calibration values from the physical model	 Validation in field study

Conclusions

The presented project investigates different measures and structures to initiate deep watercourses and scours that provide fish habitat especially at low flow conditions and high water temperatures. Flume experiments, numerical simulations and field studies are applied to answer the research questions. The focus of the project will be on hydraulic and morphodynamic aspects.

Bibliography

Breusers, H. N. C., & Raudkivi, A. J. (1991). Scouring (VIII). Rotterdam: Balkema.

Melville, B. (2008). The physics of local scour at bridge piers. In H. Sekiguchi (Hrsg.), Proceedings 4th International Conference on Scour and Erosion (ICSE-4) (S. 28–40). Tokyo,Japan.

Zanke, U. (1982). Grundlagen der Sedimentbewegung : mit 13 Tabellen (XII). Berlin; Heidelberg [u.a]: Springer.

Sheppard, D. Max ; Odeh, Mufeed; Glasser, T. (2004). Large Scale Clear-Water Local Pier Scour Experiments. Journal of Hydraulic Engineering, 130(10), 957–963. https://doi.org/10.1061/(ASCE)0733-9429(2004)130:10(957)