Marie Skłodowska-Curie

Innovative Training Network

"HypoTRAIN"

Hyporheic Zone Processes – A training network for enhancing the understanding of complex physical, chemical and biological process interactions

Grant Agreement No. 641939

Deliverable D1.3

Multi-scale modelling framework

Dissemination Level of Deliverable:

PU	Public	**X**
CO	Confidential, only for the members of the consortium (including the Commission Services)	

Content

Multi-scale modelling framework

1. Aim of the approach and expected results

The goal of this part of HypoTRAIN research was the development and validation of an integrated multi-scale modelling framework for the identification of hyporheic exchange flows and residence time distributions. One specific aim was to show the effect of large-scale groundwater circulation on the hyporheic flow.

2. Brief description

Due to the strong effect of deep groundwater circulation on hyporheic exchange fluxes, a multi-scale approach is required to reach a comprehensive understanding of complexity of hyporheic zone processes. For this the effect of catchment scale upwelling of groundwater on local hyporheic fluxes was investigated. Specifically, site specific landscape morphology and its geological heterogeneity are accounted for. Our approach is based on applying a superposition method on regional groundwater flow and local hyporheic fluxes.

3. Method development

The multi-scale approach presented here makes use of two different spatial scales reflecting large scale surface topography as a proxy for the groundwater surface and local scale topographic control of head fluctuations governing the hyporheic flow. Finally, due to the linearity in the governing equations, the regional groundwater flow field can be superimposed on the local hyporheic flow field, which facilitates a study of the effect of the regional groundwater flow on the hyporheic zone.

3.1 Catchment scale model

Numerical softwares (COMSOL Multiphysics, MODFLOW, MIKESHE, etc) are used to model the large scale groundwater circulation:

- Investigating the groundwater flow field highly depends on the characterization of the water table. The regional water tables are generally classified as either “topography-controlled” or “recharge-controlled”.
- Dividing the catchment into two layers: Quaternary Deposit (QD), and bedrock
- Including the heterogeneity of hydraulic conductivity by using soil type map
- Applying depth decaying hydraulic conductivity based on empirical equations

- Considering appropriate boundary conditions depending on water table classification.

3.2 Hyporheic scale model

The local hyporheic flow field is modeled using a fractal re-scaling of the surrounding landscape topography of the river to form the local stream topography using known principles. The reason for using such a rescaling is that the stream topography is difficult to be determined in detail across an entire watershed:

- Generating high resolution data for topography by rescaling the amplitude spectrum of the real topography
- Converting topography into hydraulic head using a static damping factor, a dynamic amplitude factor, and a shielding effect due to the depth of the HZ

3.3 Superimposed model

- Extracting the velocity results of the regional and hyporheic scales with a same resolution of hyporheic scale
- Superimposing the results of these two distinct scales
- Analyzing the effect of the regional groundwater flow field on the hyporheic flow using the residence time distribution and the spatial extent of losing and gaining conditions