First experimental and simulation results of bank-side extraction well field tests to influence water exchanges in the hyporheic zone

Véronique Durand¹,², Maria Fernanda Aller¹, Richard B. Greswell¹, Michael O. Rivett¹, Rae Mackay¹, John H. Tellam¹

¹School of Geography, Earth & Environmental Sciences, University of Birmingham, UK
²Now at UMR 8148 IDES, Bât 504, Faculté des sciences, Université Paris Sud 11, 91405 ORSAY Cedex, France, veronique.durand@u-psud.fr

Introduction

Hyporheic zone (HZ)
- Exchanges between the ground and river waters
- Biogeochemical processes controlled by the exchanges
- Influence of hydraulic conditions on exchanges

- Hypothesis: stable head as a boundary condition in the aquifer
- If river level decreases → HZ hydraulic head increases (A to A' → a to a')

Problematic
- What is the sensitivity of the HZ hydraulic head to river level variations?
- Can a long-term pumping test control the surface-ground water exchanges?

Method: coupled field test/modelling approach
- 10 m wide, 20cm-2m deep river (mean discharge ~2 m³/s)
- Well 5 m adjacent to the river, 16 m deep
- Heads and quality monitoring in the riverbed

Test site:
- Urbanised reach of the River Tame, Birmingham (UK)
- Alluvial-drift deposits overlying ~100m of Permo–Triassic sandstone

Results

Simulated hydraulic heads in cross-section view under natural flow regime

Unrealistic simulation of HZ heads under a linear increase of the river level

Base hydraulic conductivities:
- Kr=2m/d (Riverbed)
- Kg=5m/d (Made ground)
- Ka=5m/d (Alluvium)
- Kg=1m/d (Sandstone)

Measurements and realistic simulation inspired from the same river level variations

- On this plot: small flood event (~40cm) compared to others observed (increase of river level up to 2m)
- Daily variations (3cm) observed in the river → influence on HZ heads

Conclusion

- High sensitivity of HZ heads to three factors:
  - River level (major during flood events)
  - Aquifer conditions (higher influence at low river levels)
  - K heterogeneities

- Impact of pumping (100 l/mn)
  → decrease of HZ hydraulic head ~6cm
  → Decrease in Kr (half value)
  → increase of HZ head ~3cm
  → Decrease in Ka (~half value)
  → decrease of HZ head ~4cm

Perspectives

- Calibrate the spatial K heterogeneities
- Take into account the chemical parameters
- Analyse the temperature variations within the riverbed