Is electrical conductivity an effective surrogate for solute concentration in tracer injection experiments?

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Introduction

- Tracer injection studies require time-consuming, laborious and costly water samples collection and analysis, which normally results in temporally limited tracer breakthrough data.

- Electrical conductivity (EC), a measurement of water ionic content has been used to quantify tracer breakthrough in injection experiments.
  - EC potentially improves data resolution, generating detailed and high-frequency breakthrough curves (BTCs);
  - EC is less expensive and easier to obtain.

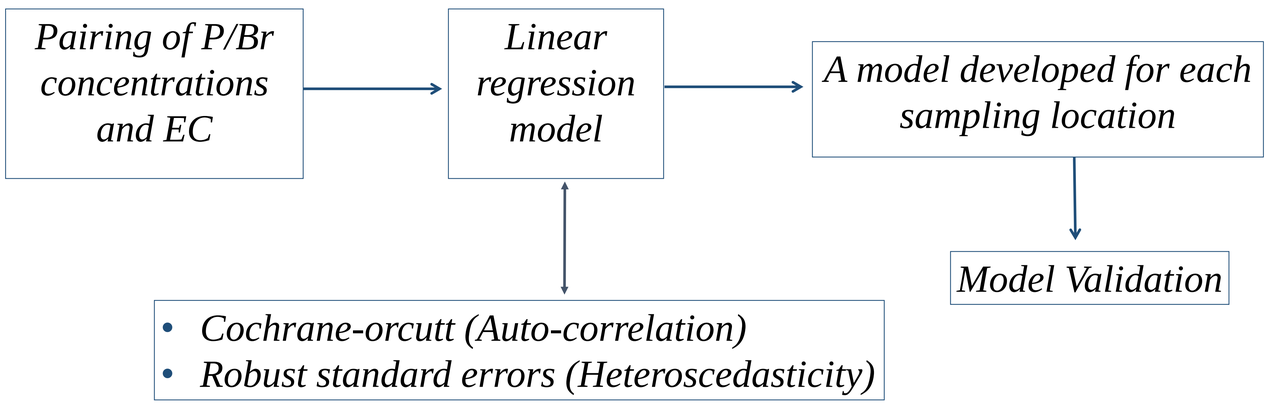
- OBJECTIVE: To evaluate whether EC can be effectively used as a surrogate for phosphorus (P) and bromide (Br) concentrations – respectively, a reactive and a conservative solute - in constant and instantaneous injections under different subsurface hydrology.

Methods

Figures 1(a) and 1(b): 20- flume and 10-m flume used in the instantaneous and constant injections, respectively.

Table 1: Design of the experiments. The solute concentrations and EC were monitored along the flumes in 4 different locations.

	Number of data points	P concentration (mg L $^{-1}$)	Br concentration (mg L $^{-1}$)	Electrical conductivity (µS cm^{-1})	Hydrological conditions
Pulse injections (20 m)	110	✓	✓	✓	Saturation, Drainage and Seepage
Constant injections (10 m)	160	✓		✓	Saturation and Drainage

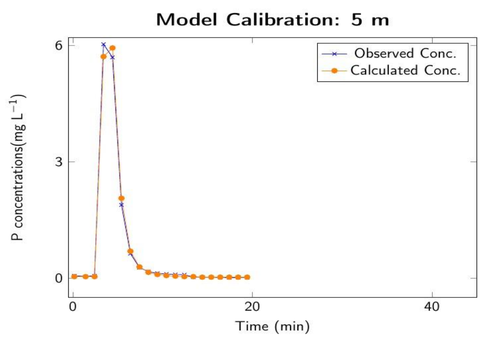


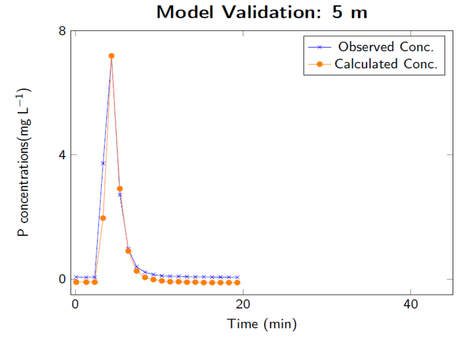
Selected results

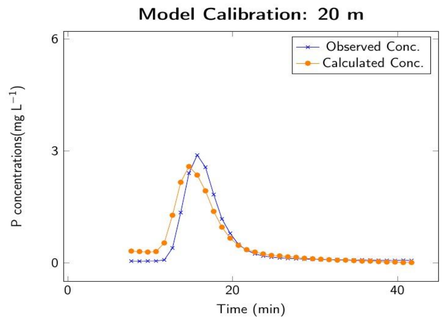
Table 2: Fitness of the models estimated for the instantaneous injection under saturation.

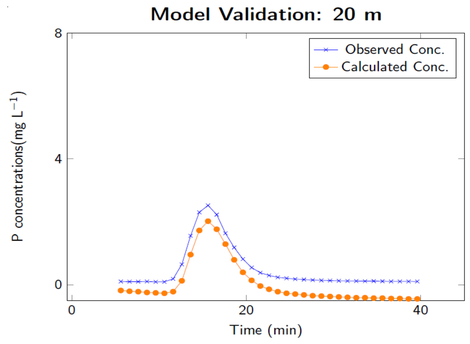
Sampling Location	5 m	10 m	15 m	20 m
EC vs. P concentrations				
Adjusted R^2	0.997	0.966	0.988	0.7296
EC vs. Br Concentrations				
Adjusted R^2	0.999	0.972	0.995	0.691

EC vs. P concentrations

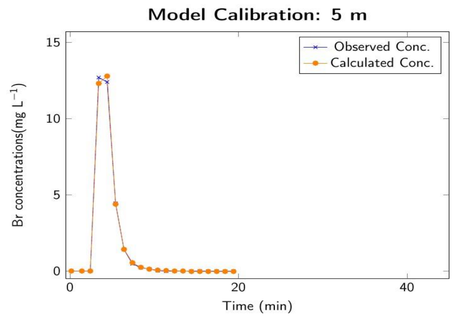


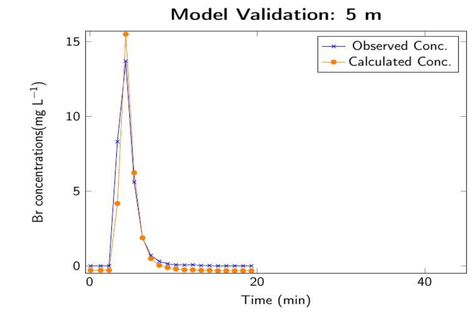


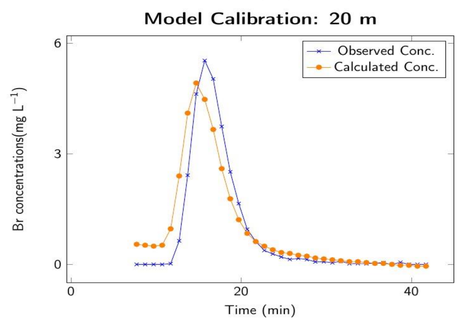


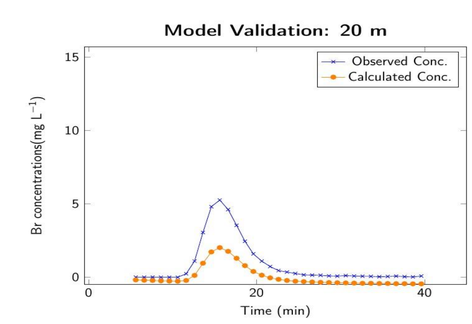


EC vs. Br concentrations









Preliminary conclusions

- The models showed a good fit between EC and P/Br concentrations, however, EC does not seem to be a robust parameter to be used as an exclusive surrogate for solute concentrations in tracer injections.
- As water travels downstream, EC becomes less effective in predicting P/Br concentrations, due to the greater influence of the media and/or the lower solute concentrations, e.g., comparing the 5-m and 20-m fits.
- Future work: How to collectively interpret the models developed from multiple experiments?