Evaluation of Electrical Conductivity as a Surrogate for Solute Concentration in Tracer Injection Experiments

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The transport of nutrients in streams depends on a series of chemical, biological, physical and hydrodynamic processes. Tracer injection is a commonly used technique in studying in-stream solute transport processes. However, these studies require costly and time-consuming sample collection and solute analyses. Moreover, the sampling interval is usually limited, which results in temporally limited tracer breakthrough data.

The measurement of electrical conductivity (EC) in water appears as an alternative technique to these dispendious procedures of water sampling and analyses. Its greatest advantage is the improvement on data resolution, resulting in high-frequency breakthrough curves (BTCs). From well-defined BTCs, solute transport metrics can be precisely calculated (Gooseff and McGlynn, 2005).

Furthermore, EC measurements are less expensive and easier to obtain. Some injection studies have used EC data solely as the primary parameter to quantify solute transport without measured solute data. A possible disadvantage of using EC as the single parameter in stream tracer injections is the fact that is does not necessarily account for temporal and spatial variations due to lateral inflows and upstream boundary conditions (Gooseff and McGlynn, 2005).

This research is designed to evaluate EC data as a potential surrogate for solute concentrations in tracer injection studies. The proposed method establishes a direct relation between EC and ionic concentration datasets, which were concurrently collected in separate instantaneous and constant injection experiments. The two injection studies were conducted in two separate ditch flumes (Figures 1 and 2).

Figure 1. 20-m flume used in the instantaneous injection study (Yoder, 2013).

Figure 2. 10-m flume used in the constant injection study.

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The first study involved an instantaneous co-injection of conservative (bromide, Br) and reactive (phosphorus, P) tracers in a 20-m flume. The experiments were conducted under different subsurface hydrological conditions, simulating a losing, a gaining and a neutral stream. The second study was a constant injection of P in a 10-m flume. The study was conducted by adding 1 ppm and 5 ppm P solutions under two distinct subsurface hydrological conditions: drainage and saturation. In both studies, discrete water samples were collected at the same 4 locations where EC meters recorded EC measurements continuously. The water samples were later analyzed for Br and P concentrations, resulting in breakthrough curves, such as the one shown on Figure 3 for soluble P. The correspondent EC dataset is also shown in Figure 3.

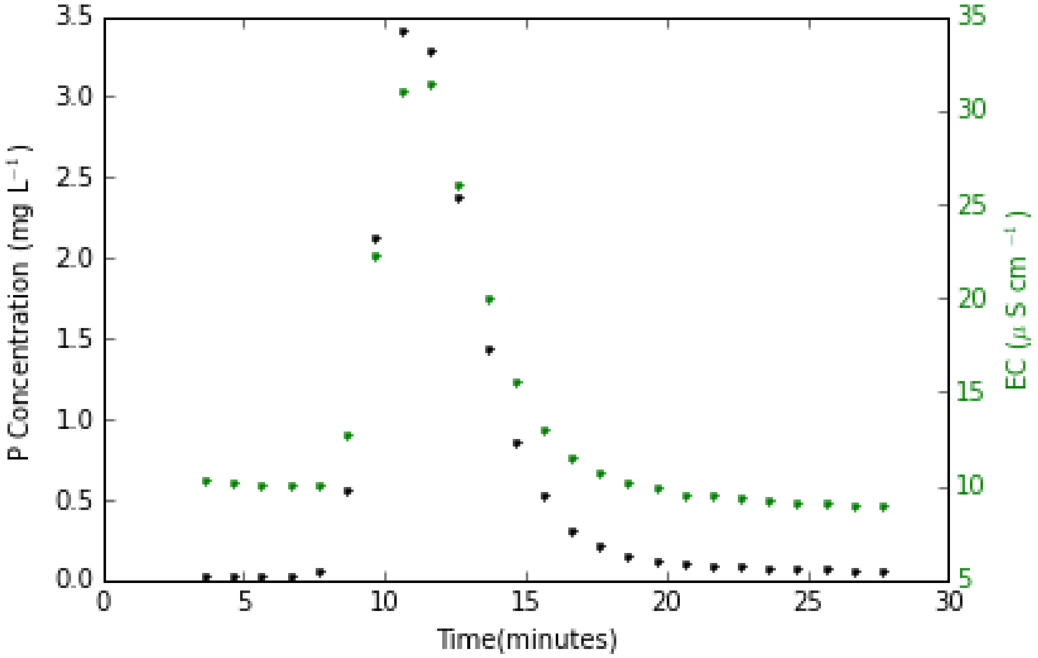

Figure 3. Example of P Concentration and EC datasets. This example is from an experiment with instantaneous injection conducted under saturation.

In this presentation, we will discuss the capability of using EC readings to infer Br and P concentrations and how to collect calibration samples to establish the EC vs. concentration relationship. A validated EC to solute concentration conversion can lead to significant cost and labor savings in stream injection studies, and therefore, facilitates the study of solute transport processes. Preliminary results show a significant correlation between P concentrations and EC in the instantaneous injections, suggesting that the latter is a reliable parameter in the evaluation of nutrient transport processes in this type of studies.

References

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