

Measuring transient storage (dye injection method)

Transient storage is defined as any physical aspect of a stream temporarily holding water such as pools, backwater, and the hyporheic zone. Measurements of transient storage in a stream system indicate the direction of surface-subsurface linkages (e.g. upwelling, downwelling or non-welling zones) and can characterize the transport rate of dissolved materials.

Materials

NaCl - Canning salt dissolves the most thoroughly, although table salt works, too. Just don't get iodized.

Mariotte bottle (Carboy) - Any size big enough to hold your solute mix - this could be up to a 20-L carboy depending on duration and rate of injection

Spigots and Tubing for Mariotte - You'll need to connect the end of the spigot to a tube long enough to reach the stream - there are little plastic hardware pieces to make the connection leak-free.

Rubber stopper and rigid hollow tube - Take off the lid that the carboy comes with and put in an air-tight rubber stopper. Drill a small hole in the rubber stopper and slide/squeeze through a small-diameter rigid (e.g., glass) hollow tube that reaches as close to the floor of the carboy without touching -- this is a pressure control so that your gravity-flow injection rate remains constant regardless of head in the carboy. Smear some "AquaSeal" around the hole in the stopper to ensure that the only air leaving the carboy is via the tube. Once you've got this stopper device made, take good care of it and don't mess with the tube.

Electrical conductivity meters (3-4)

Field notebooks - Individual field forms on clipboards have been tested, but time and time again people prefer to have a pocket-sized Rite-in-Rain notebook rather than fumble with a clipboard, especially if people are going back and forth between transects.

Stirring device - Or, if you saved the original threaded cap to the carboy, then you can shake the carboy with the solute in it to thoroughly mix it, and then just replace the rubber-stopper pressure top. This is far more reliable than stirring.

WT Rhodamine Dye

Methods

Release a bit of Rhodamine WT dye into the stream (either on a previous visit or the same day) at your desired injection point, and follow it downstream until it appears totally mixed with the stream water, both vertically and laterally. Mark that point -- that's the "0-meter" transect, and the length the dye traveled is your mixing length (write that down, too - it may come in handy!). Rhodamine won't interact with salt, so there's no problem doing this the same day.

Mark your sampling transects. Typical lengths range from 20-50 m in small streams, to several hundred meters in larger streams. This is a bit of a task, finding the right reach length. If you're going to use software to estimate parameters such as exchange rates with transient storage zones, size of storage zones, etc..., then there is a wealth of literature available to help you find the reach length that would optimize these estimates. If you're going to do a basic mass-balance of the solute, with your primary interest being how much solute is retained and for how long, then reach length depends on the channel forms you want to study (e.g., a reach encompassing a log jam, or a sequence of pool-riffles).

Mix the non-iodized NaCl with stream water (238 g/liter) in the carboy, ensuring that the salt is completely dissolved. Total volume needed depends on the release rate and reach length. Use the following equation to determine release rate:

$$Q_i = Q * C_s / C_t$$

where Q_i is the injection discharge rate, Q is streamflow, C_t is the target stream concentration, and C_s is the injection concentration. Target stream concentration is 5-10 fold that of background. Bring plenty of extra salt to the field so as to mix more solute if necessary! In this case, so as to not interrupt the constant injection, bring a second carboy system to turn on at the same time the first one goes dry.

For higher injection rates and larger solute volumes, use a metered pump and trash barrels to mix/hold the solute. (the Center has a FluidMetering Inc. pump and two large trash barrels for this). The pump can be drawing on one barrel of solute as you mix more in the second barrel. Well-mixed solute can then be transferred to the pump-barrel as needed. When using the barrel/pump method, make sure that the intake tube in the barrel is always floating on the surface of the water to avoid effects of elevation head. **Always** take care with the pump, rinse with clean water after use, and service the piston following the strict instructions in manual. Salt build-up will ruin it.

Calibrate the conductivity meters; first in the lab to standards, and then to each other in the field on the day of the injection.

Synchronize stopwatches. If someone accidentally stops their stopwatch during the experiment, he/she can restart it and record the stopwatch time of another person at the moment they restart.

Place the Mariotte bottle on a stand directly in the stream or on the bank so that the solution enters a turbulent, well-mixed zone.

With a bucket under the spigot, open Mariotte bottle fully to allow it to equilibrate. Once the gurgling has stopped and solute flows out freely, turn off the spigot. This process needs to be repeated if air enters the carboy. Don't let any solute enter the stream yet!

Choose a pipette tip size that provides the desired release rate when connected to the end of the release tube. Calibrating the aperture of a pipette tip so that you can open the spigot 100% and have the correct release rate is easier to deal with than calibrating how much to open the spigot. Several pipette tips of correct aperture should be labeled and available in the field as back-up.

Record background conductivity at each sampling transect.

Release salt concentration; record the time on your stopwatch when you begin this.

Read and record time and conductivity at regular intervals; often every 30 seconds.

Turn off spigot when the conductivity of the most downstream transect has plateaued for at least 5 minutes. Record this time.

Continue taking readings every 30 seconds until conductivities reach background levels (prerelease) at ALL transects.

Take surface water samples (in triplicate) at background, during the rise, at plateau and during the fall of the injection for subsequent laboratory chloride analysis. This information is required to relate conductivity readings back to chloride concentration. Remember, conductivity is only a good surrogate of Cl if you can relate it to Cl! Submit the Cl surface water samples to the lab immediately following the injection. Freeze one of the three replicates for later analysis if data appear anomalous.

Notes

If a Chloride probe is available, skip conductivity all together and eliminate a lot of work! (As of 2002, the Center does not own one).

References

Hauer, F.R. and G.A. Lamberti. 1996. *Methods in Stream Ecology*. Academic Press. San Diego, CA.