Comparison of Stream Reach Scale Transport of Rhodamine WT and NaCl in Coupled Mountain Stream-Hyporheic System

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Introduction:

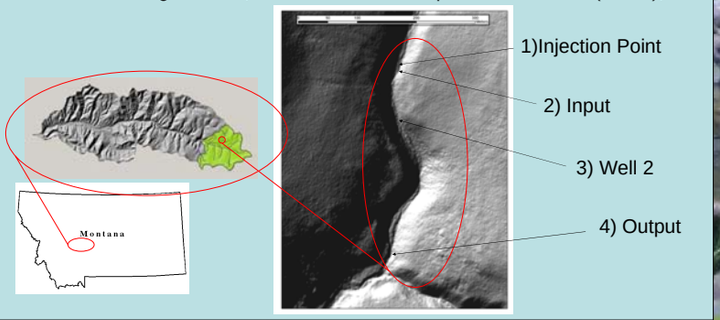
Rather than interpret the late-time behavior of rhodamine WT (RWT) breakthrough curves in stream tracer studies as indications of hyporheic exchanges we suggest that RWT is lost by sorption. We assessed the transport of RWT compared with NaCl during and after a 5 hour co-injection steady state drip experiment conducted in a headwater mountain stream.

We hypothesize that RWT is not transported conservatively compared to the NaCl tracer. Furthermore, we hypothesize that this relationship between RWT and NaCl transport can be seen both along the stream reach scale and across the sediment water interface.

Goal:

1) Observe and measure RWT transport along the stream reach and into the hyporheic zone. 2) Quantify RWT loss.

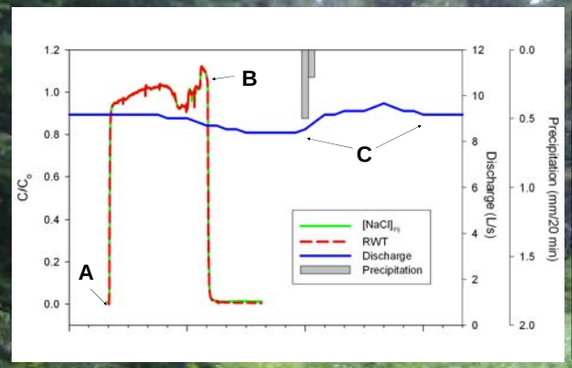
Site: Middle Stringer Creek, Tenderfoot Creek Experimental Forest (TCEF), MT.



Methods:

- Target concentration levels: 40 mg/L $[NaCl]_{inj}$, 95 ppb RWT.
- Campbell Scientific CR500 and CR10X data loggers collected electric conductivity (EC) data from locations 1, 2, and 4.
- Turner Designs SCUFA Submersible Fluorometer meters collected fluorescence data for RWT concentrations at locations 2 and 4.
- Water samples were collected every 1/2 hour from locations 2, 3, 4 (plus 3 additional wells and 2 additional stream locations).
- EC was measured at samplings with YSI 63 and YSI 300 handheld probes.
- All EC probes were standardized and EC was converted to $[NaCl]_{inj}$ concentration.
- The samples were run with a Turner Designs 10-AU Fluorometer for RWT concentrations.

Stream Reach

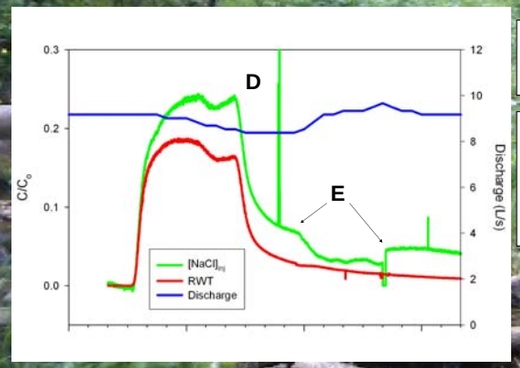


Concentration / Average Concentration During Injection - Input

A) Injection began at 10:00 on 8/15/06.

B) Injection ended at 13:00 on 8/15/06.

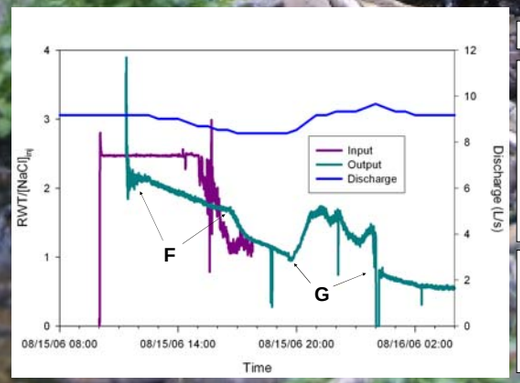
C) Notice the stream hydrograph response to a 0.7 mm storm event starting around 19:45 on 8/15/06.



Concentration / Average Concentration During Injection - Output

D) The C/C_o of RWT at the output is less than that of $[NaCl]_{inj}$.

E) Notice the NaCl response to the storm event.



RWT / $[NaCl]_{inj}$

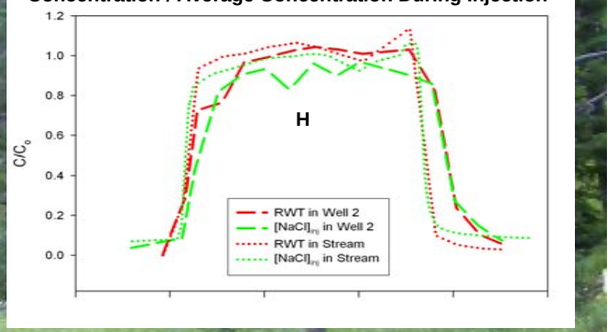
F) Over the injection plateau the RWT/$[NaCl]_{inj}$ is less – and falling – at the output than at the input.

G) Notice the RWT/$[NaCl]_{inj}$ ratio response the storm event.

Integration under the breakthrough curves at the output yielded a 52% loss of RWT and a 9% loss of NaCl during downstream transport.

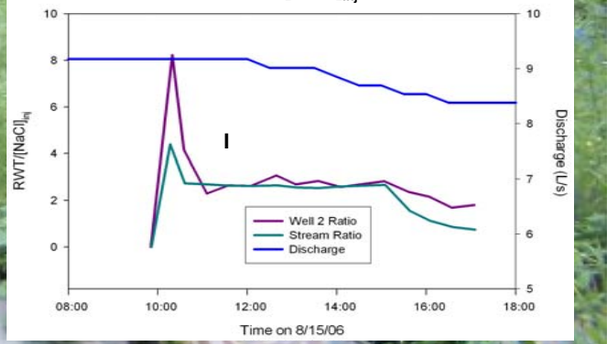
Well 2

Concentration / Average Concentration During Injection



H) Well 2 is screened 25-35 cm below the stream bed; the C/C_o breakthrough curves of the well show a time delay when compared with those of the stream.

RWT / $[NaCl]_{inj}$



I) The RWT/$[NaCl]_{inj}$ in the well shows no apparent sorption of RWT.

Results and Conclusions:

At reach scale RWT is lost when compared to NaCl.

At the sediment water interface there is no apparent loss of RWT as seen in the ratio of RWT/$[NaCl]_{inj}$ in the well compared to that of the stream.

A decay term for modeling RWT in this stream reach seems appropriate. However, given the site specific behavior of RWT it should be used as a tracer with caution.

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Abstract: The late-time behavior of breakthrough curves of rhodamine WT (RhWT) from tracer studies in streams have been interpreted as an indication of slow water paths, or hyporheic exchanges. Another interpretation of this behavior is that RhWT is being retarded during downstream transport, possibly by sorption and rate-limited desorption. In this study we assessed the transport of RhWT compared with NaCl during and after a 5 hour co-injection steady state drip experiment. The experimental stream reach was approximately 250 meters in length, ending at the Upper Stringer Creek stream gage in the Tenderfoot Creek Experimental Forest, MT. Electric conductivity (EC) and fluorescence concentrations were measured with data logging probes (every 10 seconds) located 1) at the end of a mixing length downstream of the injection point (input - approximately 16 meters downstream), and 2) at the Upper Stringer Creek stream gage (output - approximately 250 m downstream). We then converted EC time series to NaCl concentration time series for data analysis purposes. Analysis and comparison of the NaCl and RhWT breakthrough curves show that 1) the ratio of RhWT concentration to NaCl concentration is lower and decreasing at the reach output compared to the input, and 2) the NaCl concentration declines for approximately 6 hours after the drip is turned off, whereas the RhWT concentration declines for over 20 hours still at detectable concentrations. These findings indicate that RhWT is being retarded over the experimental stream reach.

More Information: http://www.mines.edu/~mgooseff/web_research/hydroscapes.html