Effects of macrophytes on organic matter retention in stream ecosystems

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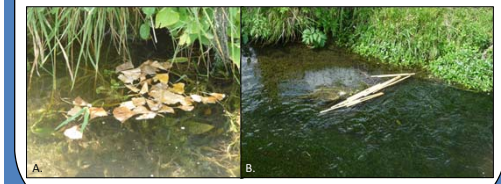
Organic Matter Retention

- In many streams, biotic function depends on energy derived from allochthonous coarse particulate organic matter (CPOM)
- Efficient processing of organic matter requires decreased rate of transport downstream (i.e., transient storage)
- Organic matter retention affects community composition, secondary production and ecosystem processes (Bilby and Liken 1980)



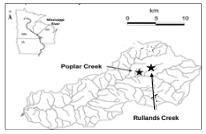
CPOM retention of A) ginkgo leaves and B) wood dowels in Poplar Creek

Macrophytes

- Macrophytes are abundant in many streams in the Upper Mississippi River watershed
- Macrophytes are important to stream ecosystem function because they:
  - Increase primary production
  - Reduce stream velocity
  - Increase surface area
  - Provide habitat and food supply
- Are macrophytes important for hydraulic and organic matter retention?


Submerged macrophytes at Poplar Creek

Poplar Creek and Rullands Creek

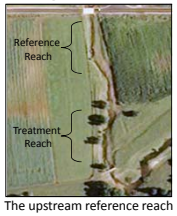


Poplar Creek and Rullands Creek are located in the Coon Creek Watershed, a tributary of the Mississippi River

- Coldwater trout streams in Vernon County, WI
- Abundant in *Ranunculus aquatilis* and *Elodea canadenis*
- At Poplar Creek the macrophyte density was 431.5 g dw/m^2 and 865.6 g dw/m^2 at Rullands Creek

Experimental Design

- The effect of macrophytes on CPOM retention and the hydrologic parameters of each stream were measured using a macrophyte removal experiment
- Each stream was divided into two 100m reaches
- The upstream and downstream reaches were the reference (no macrophyte removal) and treatment (macrophytes removed) reaches, respectively
- Releases of CPOM (ginkgo leaves and wooden dowels) and Rhodamine WT dye were conducted in each reach before and after macrophyte removal
- The streams were allowed to adjust for 7 days before post-manipulations took place



The upstream reference reach and downstream treatment reach at Poplar Creek


Removed macrophytes

Objectives

- **Determine how macrophytes affect CPOM retention in stream ecosystems**
- **Determine effect of macrophytes on transient storage area in streams**

Estimating CPOM Retention and Hydrologic Parameters

- **To Simulate CPOM Retention:** 50 wood dowels and 1,000 ginkgo leaves were released into the stream. The number of particles (sticks or leaves) collected at the end of the study reach were used to calculate the retention rate (Lamberti and Gregory 2006) using the following equation:

$$P_d = P_0 e^{-kd}$$

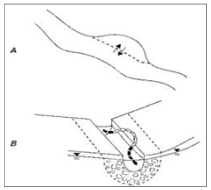
where P_0 is the number of particles released, P_d is the number of particles still in transport at the end of the reach, d is the distance of the study reach, and $-k$ is the retention rate.

- **Conservative Tracer:** Downstream transport of the dye, Rhodamine WT, was used to determine the hydrologic parameters of each reach. The dye was released into the stream at a constant rate over time (ca. 45 min) and monitored using a Hydroblab DS5 with a Turner Design Rhodamine WT Probe. The hydrologic parameters of each reach were then determined using the mathematical simulation model OTIS (Runkle 1998).

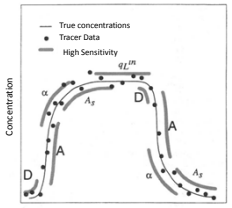

A wood dowel release at Rullands Creek


A Rhodamine tracer pumped into Poplar Creek

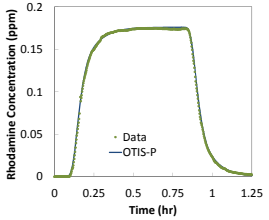
One-dimensional Transport with Inflow and Storage Analysis (OTIS)



Transient storage A) in a side pool and B) in a hyporheic zone (Runkle 1998)



Theoretical relationships among hydrologic parameters during a conservative tracer release. Dispersion (D), cross sectional area (A), storage zone exchange coefficient (α), transient storage area (A_s), lateral inflow rate (qL^{in}) (Harvey and Wagner 2000)



Example conservative tracer release data and the predicted pattern generated by OTIS

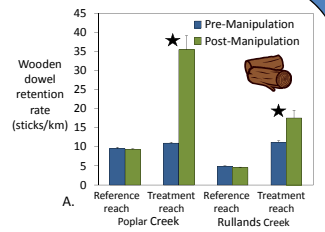
Hydrologic Parameter Results

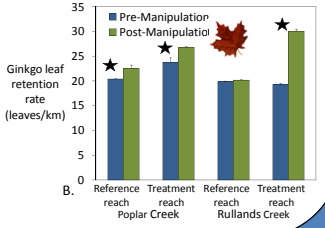
The preliminary hydrologic parameters calculated by OTIS at Poplar Creek and Rullands Creek before and after macrophytes were removed at the treatment reach.

	Poplar Creek				Rullands Creek			
	Reference reach		Treatment reach		Reference reach		Treatment reach	
Hydrologic parameter	Pre-manipulation	Post-manipulation	Pre-manipulation	Post-manipulation	Pre-manipulation	Post-manipulation	Pre-manipulation	Post-manipulation
Transient storage area (m^2)	0.19	0.14	0.12	0.10	0.29	0.30	0.25	0.23
Dispersion (m^2/s)	0.14	0.23	0.50	0.53	0.21	0.20	0.24	0.25
Storage zone exchange coefficient (s^{-1})	0.0012	0.00067	0.00039	0.00075	0.0006	0.0005	0.0023	0.0035

CPOM Results

The retention rates of A) sticks and B) leaves at Poplar Creek and Rullands Creek before and after macrophytes were removed at the treatment reach. Black stars note a significant difference at the 5% level (t-test).





Importance of Macrophytes on Transient Storage and Organic Matter Retention

- The increase in transient storage when macrophytes are present suggests that macrophytes might provide an important storage area for organic matter
- Macrophyte removal increased CPOM retention demonstrating that macrophytes promote CPOM transport by maintaining larger materials in the thalweg of the stream
- We hypothesize that macrophytes will have the opposite effect on fine particulate and dissolved organic matter. These smaller materials would be suspended in the water column, as oppose to floating on the surface, allowing them to travel into a macrophyte bed where they can be retained.

Literature Cited

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Acknowledgements

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Additional Information