New methods for estimating riverine N removal rates

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Introduction

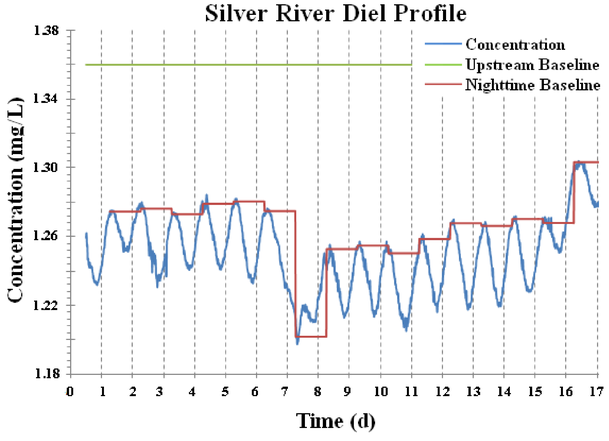
- Previous studies seeking to estimate riverine nitrogen uptake have relied on either steady-state isotope addition or pulse enrichment method.
- The costs and logistics associated with these methods preclude long-term or repeated measurements, allowing for only a snapshot of the system, devoid of the influence of diurnal, seasonal, spatial and hydrologic variability.
- Here we present two alternative methods based on a mass balance approach.
- Both allow for repeated measurements, which captures important temporal and spatial variability in uptake rates.

Submersible Ultra-violet Nitrate Analyzer (SUNA)

Image source: Satlantic

- The SUNA (Satlantic, Halifax Nova Scotia) uses ultra-violet light attenuation to measure nitrate concentration.
- It is exceedingly accurate, precise, and capable of high sampling frequency.
- It is fully automated and capable of being deployed for weeks at a time.

Eularian profiling – Temporal variation



- The SUNA is deployed at a stationary point over the course of a week or more.
- Because this study was performed in spring-fed rivers, the upstream baseline concentration is assumed constant (a two station method could also be used).
- Contributing upstream area was obtained from GIS aerial images.
- Flowrate was measured and /or obtained from USGS gauge data.
- The dissimilatory uptake rate can be estimated using the equation:

$$U_D = Q\frac{(C_B - C_N)}{A}$$

where C_B is the upstream baseline C_N is the nighttime baseline, Q is flowrate, and A is the contributing upstream area.

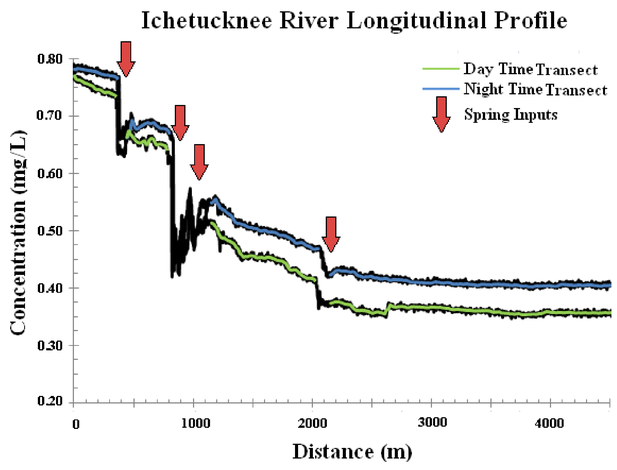
- The assimilatory uptake rate can be estimated using the equation:

$$U_A = Q\frac{(C_N - C_t)}{A}$$

where C_t is the concentration at time t.

Lagrangian profiling – Spatial variation

Image source: Google Earth



- Longitudinal transects are performed by floating downriver in a boat with the SUNA configured to sample at 0.5 Hz.
- SUNA is synced with GPS unit to record distance travelled between readings.
- Lateral inputs must be identified and mixing zones excluded from the analysis because dilution may also cause changes in nitrate concentration.
- Channel width is measured and/or obtained from GIS aerial images.
- The uptake rate for each segment can be estimated using the equation:

$$U = Q\frac{\Delta C}{\Delta L * w}$$

where Q is flowrate, ΔC is the change in nitrate concentration between readings, ΔL is the distance travelled between readings and w is channel width.

- Combines assimilatory and dissimilatory uptake, however dissimilatory component can be estimated from transects performed at night.

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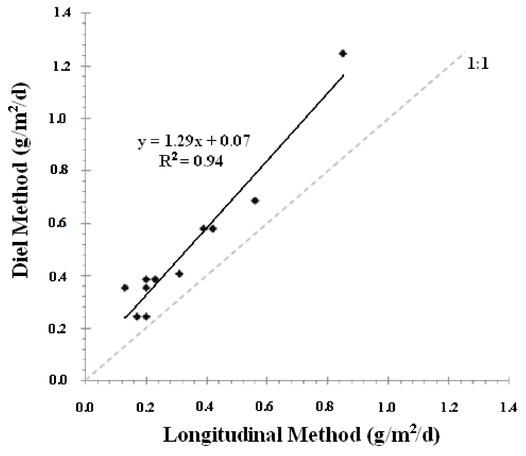
Comparison of methods

- Estimated uptake rates varied across sites from 0.13-1.25 g N/m²/day.
- Dissimilitory uptake was typically between 75 % and 90% of the total.

River	Date	U_D (g/m²/d)	U_A (g/m²/d)	$U_D + U_A$ (g/m²/d)	U (g/m²/d)
Ichetucknee River	3/2010	0.34	0.073	0.41	0.39
Juniper Creek	11/2010	0.23	0.019	0.24	0.19
Rainbow River	10/2010	1.13	0.117	1.25	0.71
Rock Springs Run	12/2010	0.36	0.032	0.38	0.17
Santa Fe (Upper Reach)	11/2010	0.29	0.067	0.34	0.13
Santa Fe (Lower Reach)	11/2010	0.29	0.067	0.34	0.20
Silver River	10/2010	0.53	0.055	0.58	0.41
Silver Glen Spring	4/2011	N/A	N/A	N/A	0.14
Weeki Wachee River	1/2011	N/A	N/A	N/A	0.20

- Across study sites, the average estimated uptake rates obtained using the two alternative methods are very similar.



- Slope indicates either diel method consistently over-estimates uptake or longitudinal method constantly underestimates uptake.

Conclusions and future work

- These new instruments and methods allow for repeated measurements of N metabolism in ecosystems, and observation of temporal and spatial variability at dramatically improved resolution.
- Future work will focus on the biogeochemical and hydrological factors that cause diurnal and longitudinal variability. What causes removal "hotspots" and "hot moments" observed in the temporal and longitudinal profiles?
- We are also working to evaluate the assumption that dissimalatory removal remains constant throughout the day given diel variation in dissolved oxygen and carbon availability.