Impacts of drying-rewetting cycles on nitrate removal in woodchip bioreactors

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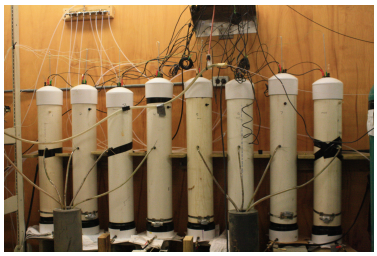
Background

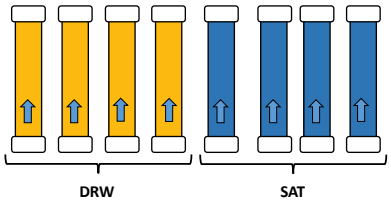
- Evidence in soils literature that alternating cycles of drying and rewetting (DRW) can stimulate microbial processes.
  - ❖ Higher CO_2 and nitrous oxide (N_2O) production[6]
  - ❖ Increased C and N mineralization[7]
  - ❖ Changes in fungal/microbial community composition[8]
- Little research on effects of DRW cycles in carbon-rich substrate (e.g. woodchip bioreactors)
  - ❖ A single DRW event increased NO_3 removal by 42%[9]

Hypothesis

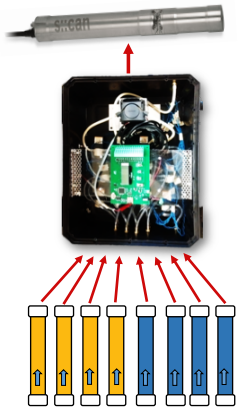
- The tested hypothesis was that **DRW cycles** in woodchip bioreactors would **improve carbon bioavailability** and **increase nitrate removal rates** upon resaturation of woodchips, **relative to woodchips that are constantly saturated.**
- We tested this hypothesis is a 287 day lab column experiment using novel multi-point sampling methods and spectrophotometric water quality analysis.

Continuous monitoring of column outflow using multi-point sampling (MPS)



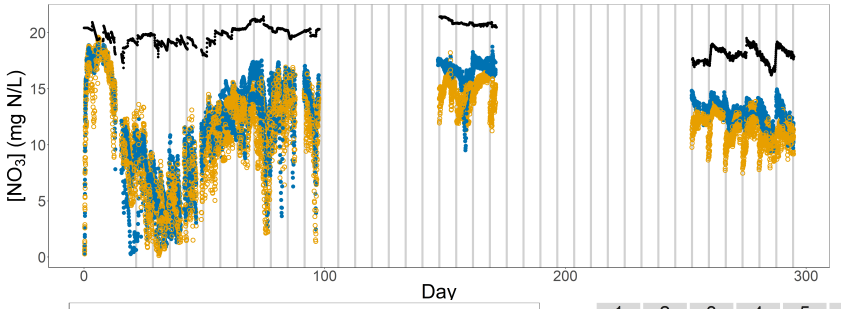


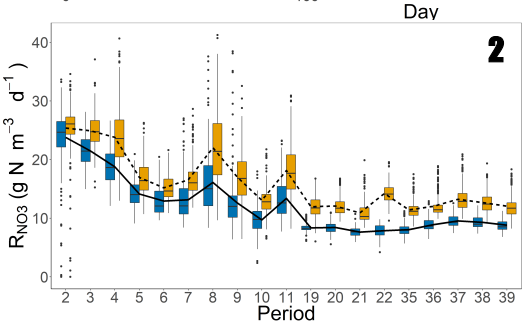
- Column study experiment
  - ❖ Upflow columns filled with woodchips obtained from 6 yr old field bioreactor.
  - ❖ Columns continuously fed nitrated tap water from stock tank (~20 mg N/L) at constant flow (~0.7 L/h) for an 8 hr hydraulic residence time (HRT).
- Eight columns, two treatments (n=4)
  - ❖ **SAT Treatment** – Columns were kept at constant saturation, continuous flow over the entire 287 days.
  - ❖ **DRW Treatment** – Columns were drained weekly and remained unsaturated for 8 hr before restarting flow and resaturating woodchips.

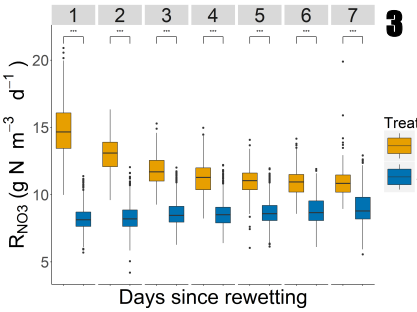


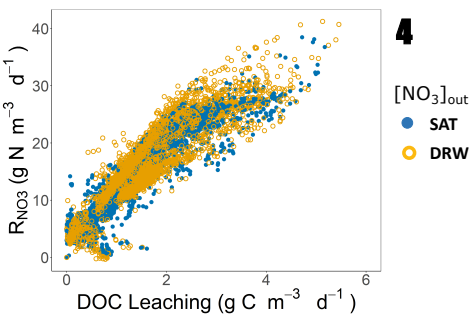
- High-frequency sampling
  - ❖ Nitrate in column outflow, $[NO_3]_{out}$, and inflow, $[NO_3]_{in}$, were measured using MPS techniques and spectrophotometer.
  - ❖ Nitrate and dissolved organic carbon (DOC) measurements on each column every **2 hr over 157 d** of the 287 d experiment.
  - ❖ Normalized nitrate removal by flow for volumetric removal rates, R_{NO3}

DRW cycles increase NO_3 removal and DOC leaching rates









1. Over 13,000 data points were collected on 8 columns over 157 days. **2.** Nitrate removal rates were consistently greater in DRW columns by 3-6 g N m^{-3} d^{-1}, even after 39 DRW cycles. **3.** Nitrate removal in DRW columns was ~80% greater on the first day after rewetting, but R_{NO3} were only 24-38% greater than SAT R_{NO3} during Days 3-7. DOC leaching (not shown) and R_{NO3} decreased with number of days since rewetting in DRW columns. **4.** Nitrate removal rates were strongly correlated with DOC leaching rates (R^2>0.9), supporting initial hypothesis of increased C availability following brief unsaturated periods.

Conclusions and implications

- This study provides convincing evidence that weekly **DRW cycles as short as 8 hr can dramatically increase NO_3 removal rates**, even after 39 DRW events. Removal is most likely linked to increased C availability.
- These findings provide a simple, *in-situ* method for water quality managers to improve performance of field bioreactors.

References, Acknowledgements

Funding for this research was provided by NIFA award #2016-67019-25279, and statistical consulting was provided by Dr. Consuelo Arellano of NCSU. References : **6.** Ruser et al., Emission of n 2 o, n 2 and co 2 from soil fertilized with nitrate: Effect of compaction, soil moisture and rewetting, 2006. **7.** Miller et al., Episodic rewetting enhances carbon and nitrogen release from chaparral soils, 2005. **8.** Gordon et al., Drying and rewetting effects on soil microbial community composition and nutrient leaching, 2008. **9.** Christianson et al., Denitrifying woodchip bioreactor and phosphorus filter pairing to minimize pollution swapping, 2017.