Reducing nutrient loading from tile drain effluent and field runoff through the use of denitrification bioreactors

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Introduction

The Salinas Valley on California's central coast is the primary source of leafy greens production in the U.S. Intensive production of these crops has been linked to elevated nitrate-nitrogen (NO_3-N) concentration in both surface water and groundwater in this region. No realistic combination of agronomic practices will consistently reduce the NO_3-N concentration of field runoff or tile drain effluent to the federal drinking water standard of 10 mg L^{-1}. One promising technique for remediation of agriculture wastewater is the use of denitrification bioreactors, in which anaerobic bacteria reduce $NO3^-$ to gaseous N compounds.

Objective

Evaluate the performance of denitrification bioreactors for the removal of NO3-N from tile drain effluent, and NO3-N, PO4-P and sediment from surface runoff.

Construction of the Bioreactors

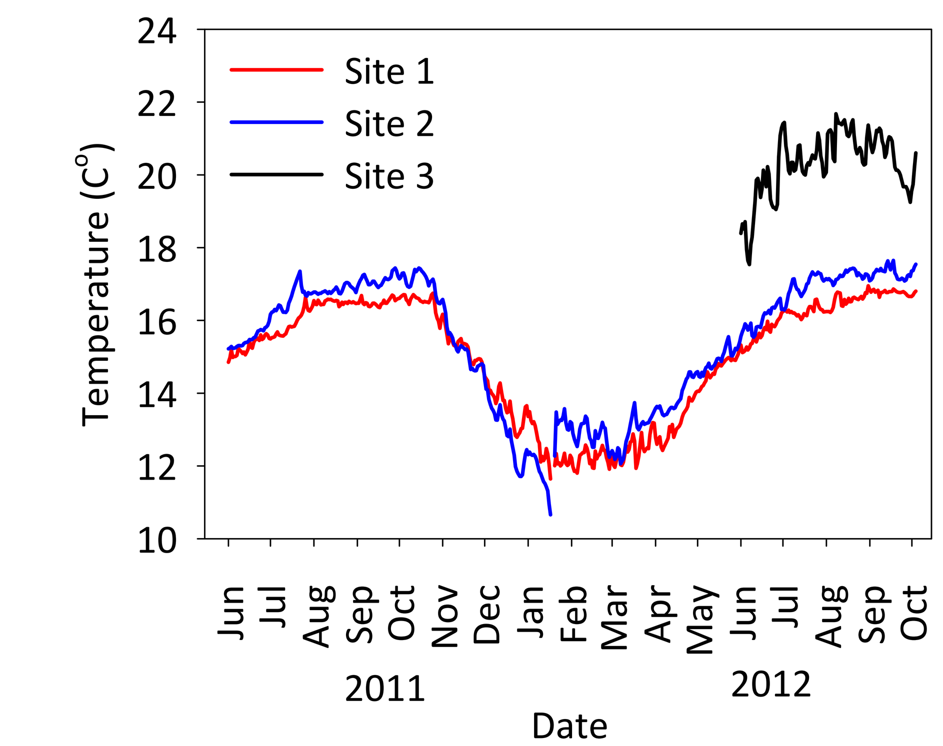
- Two pilot-scale bioreactors were constructed in 2011 on tile-drained commercial vegetable farms in the Salinas Valley in May (site 1) and June (site 2) 2011.
- Pits of approximately 26 m^3 (site 1) and 13 m^3 (site 2) were dug, lined with polyethylene sheeting (1), and filled with chipped wood waste as a source of labile carbon (2).
- Water from the tile drain sumps were continuously pumped into the bioreactors (3) at a rate to provide approximately 2 days of residence before discharge into the surface ditches draining the farms (4).
- May, 2012, a third bioreactor of approximately 12 m^3 was constructed (site 3) to evaluate the remediation of surface runoff from vegetable fields.
- This reactor was filled with the same wood waste medium, although of a finer grind.

- The runoff contained a large sediment load and high PO4-P, so a pretreatment system was developed in which polyacrylamide (PAM) and alum were injected into the runoff water, followed by about 60 minutes of settling time. This allowed flocculation of soil particles and PO4-P reduction before the runoff water was pumped into the bioreactor.

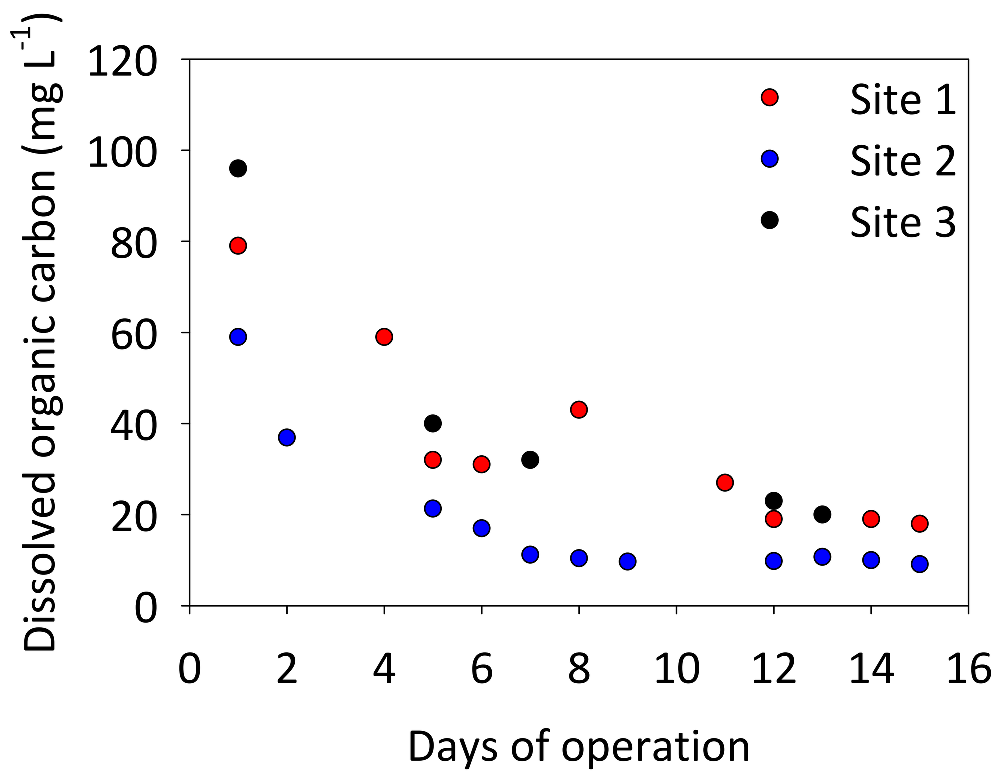
Sampling

- Tile drain effluent is supplied from collection sumps (1) and surface runoff from tailwater pretreatment (2) to the reactors.
- The inlet and outlet of the reactors have been sampled 2-3 times per week during the crop production season, and once per week during the winter.

Results

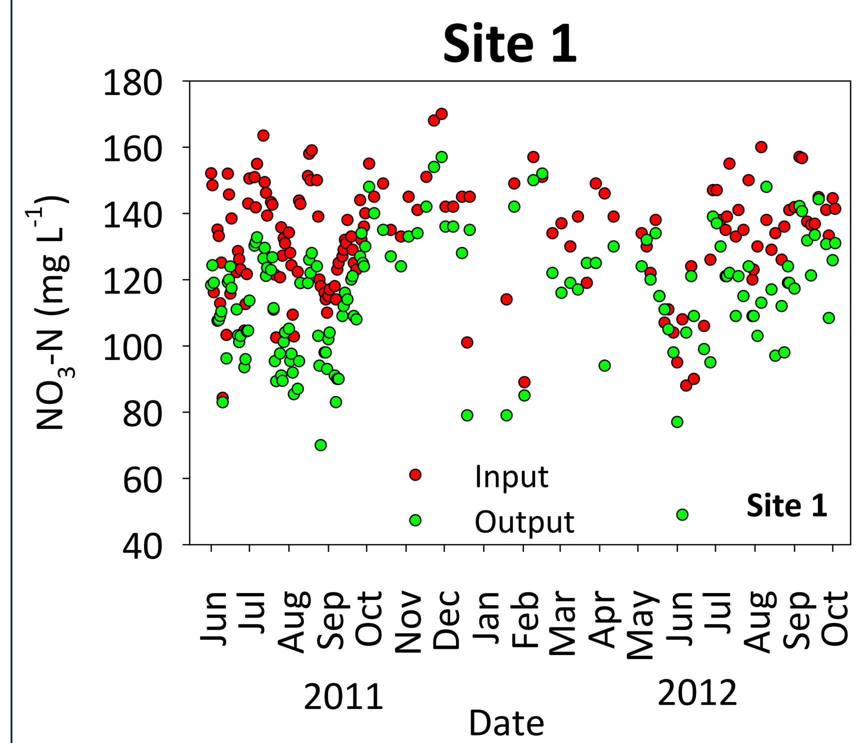


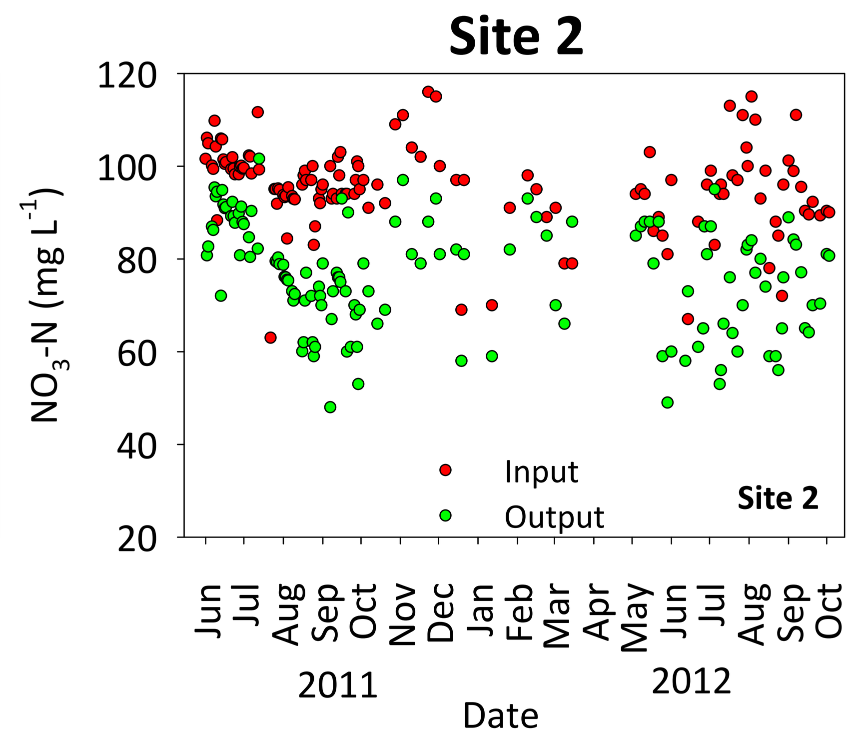
Temperatures from May 2011 through Aug 2012



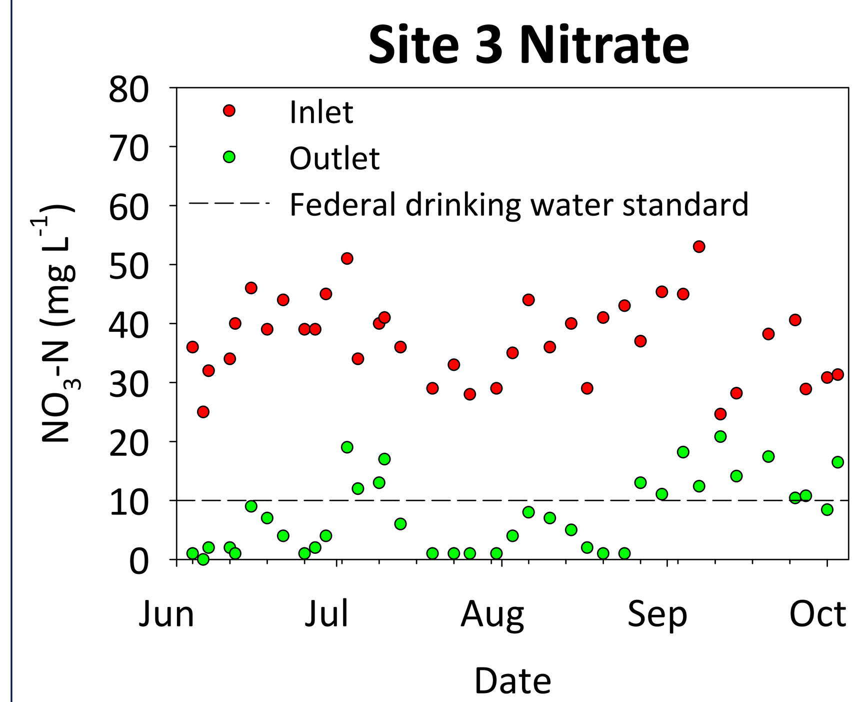
A high level of dissolved organic carbon (DOC) was present initially in the outflow from all bioreactors, but declined to approximately 20 mg L^{-1} after several weeks of operation, and stabilized at 10-15 mg L^{-1} after several months

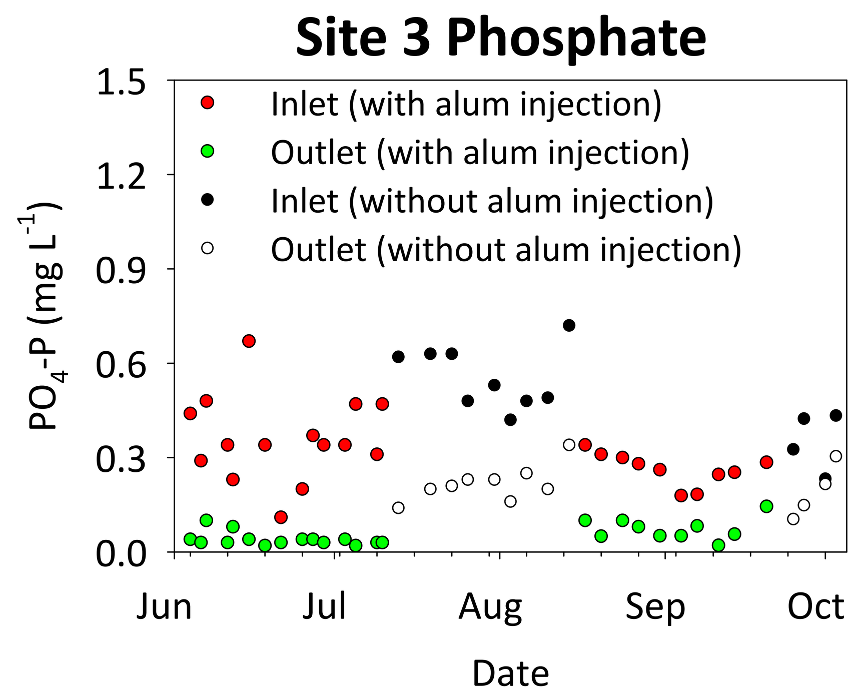
Results





After the initial month of operation, NO3-N concentration at site 1 and site 2 was reduced by approximately 8 mg L^{-1} per day of residence time during the irrigation season (July through October), and by approximately 5 mg L^{-1} during the winter.





At site 3, tailwater NO_3-N concentration ranged between 20-50 mg L^{-1}. Between 2-3 days of residence time has been sufficient to reduce NO_3-N to below 10 mg L^{-1} on most sampling dates. There was a decrease in PO_4-P concentrations with the addition of alum.

Conclusions

- The lower initial NO_3-N concentration of surface runoff compared to tile drain effluent makes denitrification bioreactors more practical for the treatment of surface runoff, provided that efficient sediment removal can be achieved.
- The costs, and the engineering constraints, of scaling up bioreactors to handle tens of thousands of gallons of tile drain effluent or surface runoff per day have yet to be evaluated.
- To be maximally effective, denitrification bioreactors would be only one element of an integrated irrigation and nutrient management system that minimizes both the volume and NO_3-N load of agricultural discharge.

Acknowledgements

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