Evaluating denitrifying bioreactors for edge-of-field nitrogen management in Iowa’s tile-drained landscapes

How can we design and operate bioreactors to optimize their nitrate removal under field conditions? This question was answered by evaluating pilot- and field-scale bioreactors to evaluate design factors (e.g., cross-sectional bioreactor shape, bioreactor length to width ratio, bioreactor volume, and retention time) and environmental factors in the field (e.g., temperature, flow rates, nitrate concentrations).

What was done and why?
The tile-drained landscape of the Midwest’s Corn Belt is one of the most productive row-cropped areas in the nation. However, the artificial subsurface drainage that fuels the region’s productivity also leads to negative water quality impacts, specifically in terms of nitrate loads. The long-term aim of the researchers is to facilitate adoption of nitrogen management and mitigation practices in Iowa and the upper Mississippi River basin. One potential route for better nitrogen control is through implementation of simple, edge-of-field practices such as denitrification bioreactors.

The project goals were to assess the performance of several denitrification bioreactors in Iowa, and to improve their applicability and cost effectiveness through advancement in reactor design and operation. Specific research objectives included:
1. Producing a bioreactor design that yields high nitrate removal from tile drainage,
2. Optimizing reactor performance under Iowa’s field conditions.

What did we learn?
The major findings included:
- Evaluation of four bioreactors in Iowa showed that they were able to remove between 12 and 57 percent of the annual nitrate load, and when averaged over all sites and years, the four bioreactors had a total load reduction of 32 percent.
- Drainage denitrification bioreactors likely will continue to be long and narrow with woodchips used as the fill media.
- The retention time, or the amount of time the water remains in the bioreactor, is strongly correlated with nitrate removal. This information can help those who design bioreactors for the future.
- Drainage water temperature and retention time are important predictors of bioreactor nitrate-removal performance. This presents design and operational challenges that have yet to be addressed such as the high drainage flow rates and cool drainage waters in spring and early summer that are key periods of drainage nitrate loading.
- Management of bioreactor control structures can provide important flexibility, especially in management of seasonally variable flow rates.