Denitrification Bioreactor in Northeast Iowa

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Introduction

Denitrification bioreactors for removal of nitrate in tile drainage are a new water quality technology that has rapidly gained interest in Iowa. A bioreactor is composed of an excavated trench filled with woodchips that are colonized by denitrifying bacteria. As drainage waters containing nitrate flow by these "good" bacteria, they convert the nitrate in the water to nitrogen gas. A critical component in evaluating the performance of these treatment systems is the documentation of nitrate-N reduction over a range in weather and flow conditions.

Materials and Methods

A denitrification bioreactor was installed at the Northeast Research and Demonstration Farm, Nashua, Iowa, April 2009. A unique feature of this bioreactor was that it was constructed with a trapezoidal cross-section, the first in the state. The bioreactor's dimensions were 120 ft long x 3 ft deep x 15 ft (top width) to 8 ft (bottom width).

Hardwood chips from a local supplier were used as fill material. Water samples were taken from the control structures by farm staff approximately twice weekly during flow conditions from 2012 through 2019. The samples were analyzed for nitrate-nitrogen at the Iowa State University Agricultural and Biosystems Engineering Water Quality Laboratory.

Results and Discussion

The bioreactor consistently reduces nitrate concentration of effluent water (Figure 1). Although flow is not shown, the periods where influent and effluent concentrations are similar are during high flow conditions where there would be low retention time in the bioreactor. Conversely, periods when concentrations of the effluent water are near zero are during very low flow conditions.

Box plots of influent and effluent nitrate-N concentrations are shown in Figure 2. From this information, the mean influent concentration was 14.0 mg/L while the mean effluent concentration was 7.3 mg/L. The median concentration was 14.7 and 7.5 mg/L for the influent and effluent, respectively. Overall, there was a 48 percent reduction in mean nitrate-N concentration and 49 percent in median nitrate-N concentration of the water that went through the bioreactor. Work continues on summarizing drainage flow information to calculate an overall load reduction due to the bioreactor.

Acknowledgements

The work of the Northeast Iowa Research Farm for the continued collection of these bioreactor water samples is gratefully acknowledged.

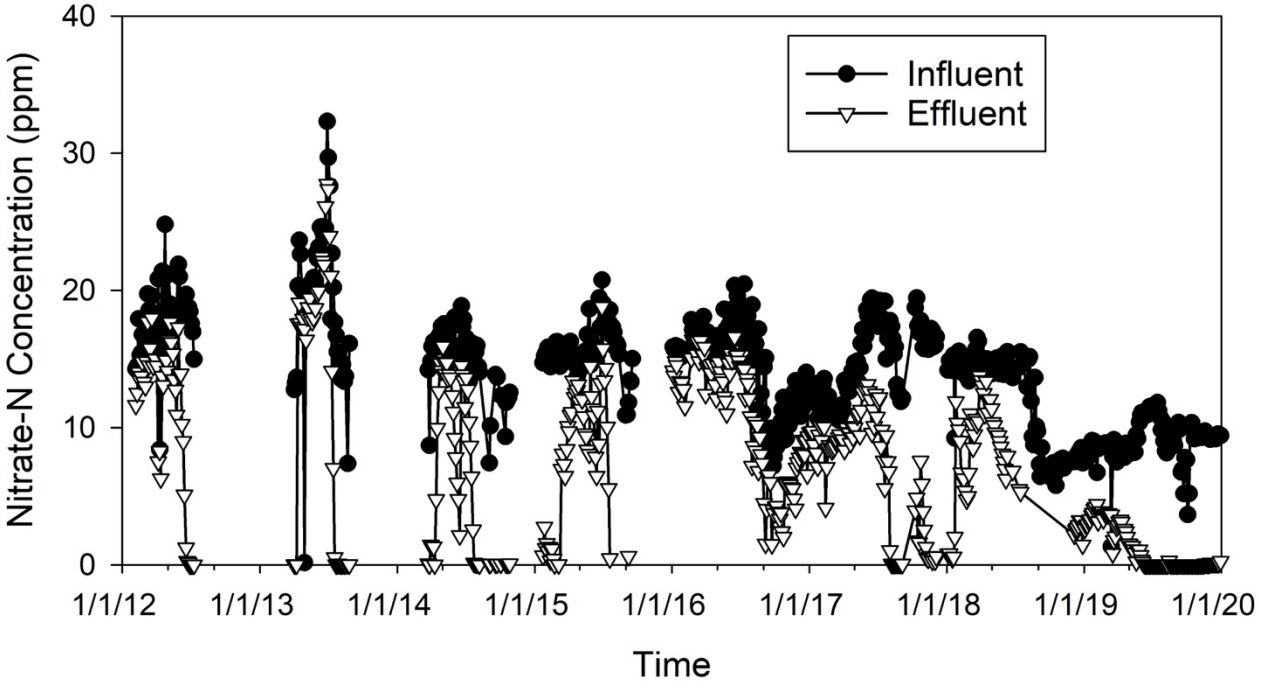

Figure 1. Nitrate-N concentrations in the bioreactor influent and effluent from 2012-2019.

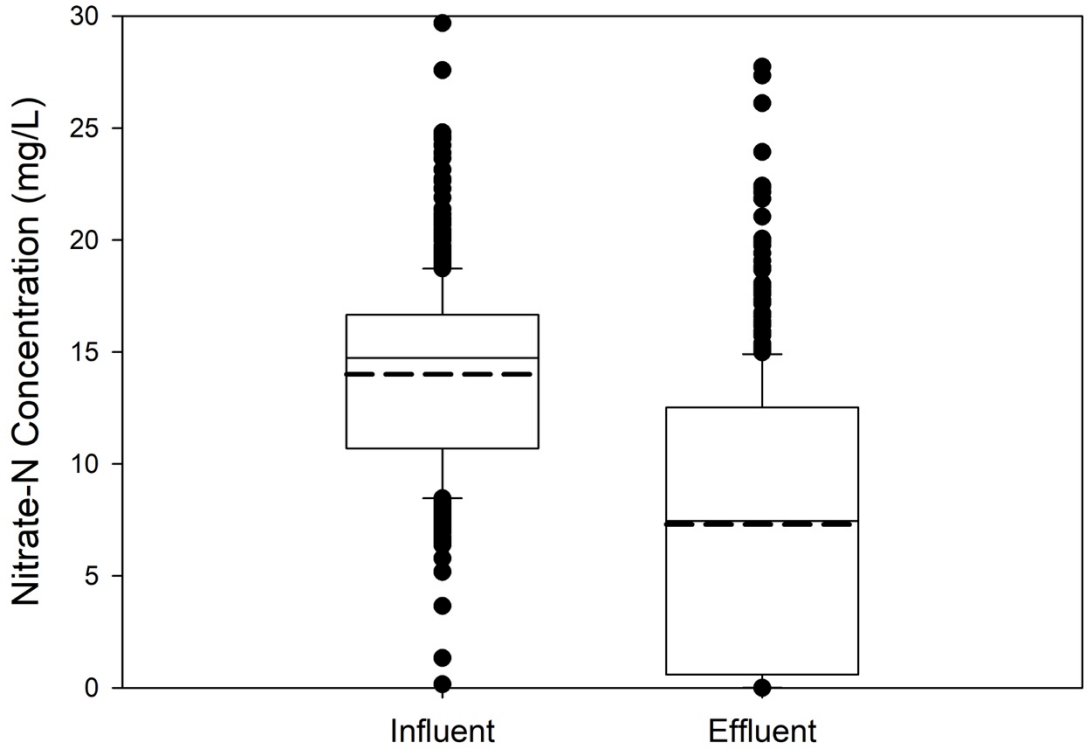

Figure 2. Box plot of nitrate-N concentrations in the influent and effluent from the bioreactor for 2012-2019.