Denitrification Bioreactor in Northeast Iowa

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Introduction

Much of Iowa's agricultural fields have subsurface tile drainage to improve a crop's growing conditions. Although the tile drainage removes excess water from the field, it also transports nitrate, a water quality impairment, downstream. A relatively new edge-of-field technology, referred to as a denitrification bioreactor, has been developed to reduce the nitrate levels in the tile drainage. The bioreactor is essentially an underground trench filled with woodchips that intercepts the tile drainage. "Good bacteria" in the bioreactor convert the nitrate in the tile drainage into nitrogen gas, improving the water quality.

Materials and Methods

A denitrification bioreactor was installed at the Northeast Research and Demonstration Farm, Nashua, Iowa, in April 2009. This bioreactor is unique as it was constructed with a trapezoidal cross-section, the first to do so in the state. It also now is one of the oldest operating bioreactors in the state. The dimensions are 120 ft long x 3 ft deep x 15 ft (top width) x 8 ft (bottom width).

The woodchips used as the fill material are of a hardwood variety sourced from a local supplier. Water quality samples have been collected from the control structures by farm staff approximately twice weekly during flow conditions from 2012 through 2020. The samples were analyzed for nitrate-nitrogen at the Iowa State University Water Quality Research Laboratory.

Results and Discussion

The bioreactor consistently reduces the nitrate concentration of the effluent water. Periods when the greatest nitrate removal occurs are typically at times when the temperature of the tile drainage is warmest (Figure 1). Another factor in the nitrate removal is the volume of tile drainage flow, which is not shown in this report. Typically, periods of lower flow also will correspond to greater nitrate removal than periods of higher flow. This occurs due to a greater residence time of the tile drainage in the bioreactor during lower flows than at higher flows, i.e., the "good bacteria" have more time to remove the nitrate.

Box plots of influent (collected from the inlet control structure) and effluent (collected from the outlet control structure) nitrate-N concentrations are shown in Figure 2. From this information, the mean influent concentration was 13.2 mg/L while the mean effluent concentration was 5.8 mg/L. The median concentration was 14.2 and 3.3 mg/L for the influent and effluent, respectively. Overall, there was a 56 percent reduction in mean nitrate-N concentration and 77 percent in median nitrate-N concentration of the tile drainage that went through the bioreactor. Research is continuing to work on summarizing drainage flow information to calculate an overall load reduction due to the bioreactor. A new water quality parameter, orthophosphate, study began in 2020. These samples are still in the process of being analyzed and this data will be further analyzed once available.

Acknowledgements

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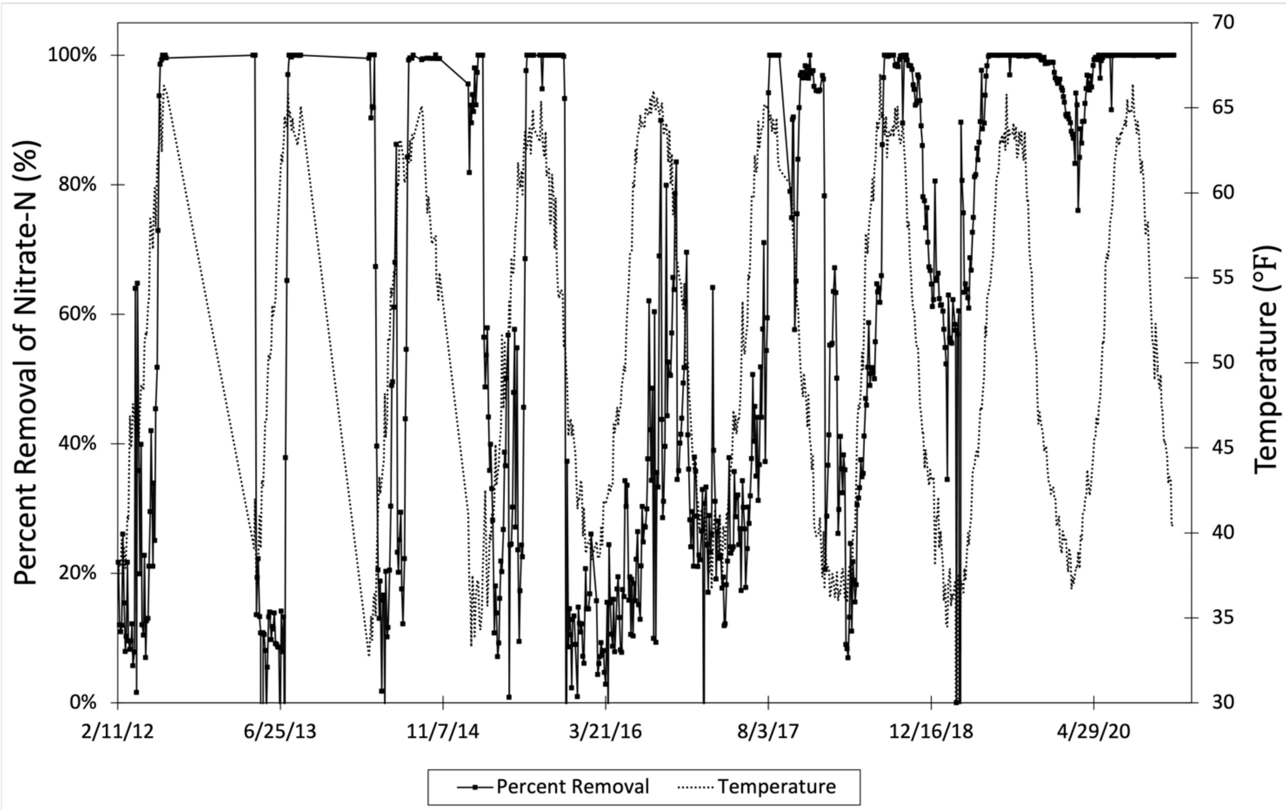

Figure 1. Percent removal of nitrate-N in the bioreactor influent and effluent from 2012-2020 with respect to temperature of the influent during the same period.

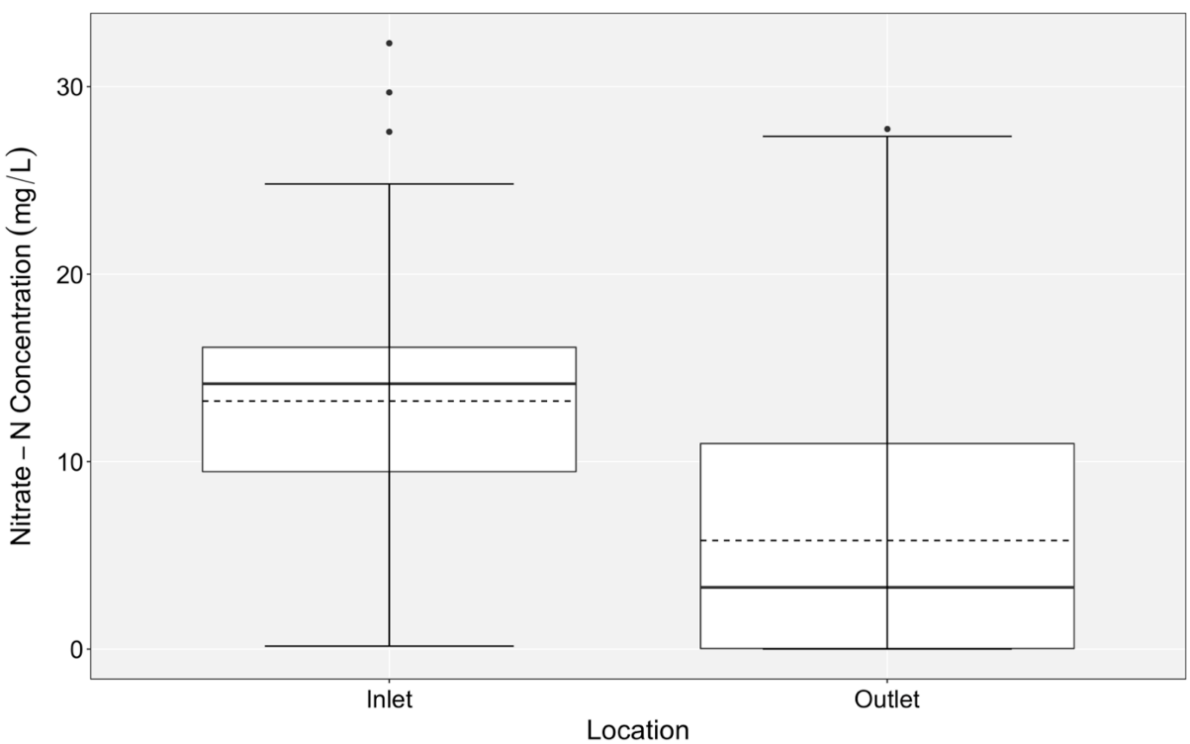

Figure 2. Box plot of nitrate-N concentrations at the inlet and outlet of the bioreactor for 2012-2020. The solid line represents the median concentration while the dashed line represents the mean.