Experimental Tile Drainage Denitrification Bioreactors: Pilot-Scale System for Replicated Field Research

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Introduction

Bioreactors play a prominent role in the Iowa Nutrient Reduction Strategy's goals to achieve 41 percent nitrate reduction from non-point sources. Two of the three detailed scenarios in the Nutrient Reduction Strategy incorporate heavy adoption of bioreactors; one with 60 percent of tile drained land treated, and one with 70 percent of tile drained land treated. With a push for increased bioreactor installation, field research to evaluate and improve bioreactor design and function is invaluable.

Materials and Methods

Nine pilot-scale bioreactors were installed at the AEA Research Farm in 2014 (42° 1'1.53"N, 93°46'47.76"W). In 2015, a bromide tracer study was conducted on each of the nine bioreactors to evaluate and confirm similar flow characteristics between the replicated pilot-scale system. The first year of experimentation at the site was initiated in 2016 to evaluate nutrient removal, greenhouse gas (GHG) emissions, wood chip mass loss, and wood chip microbial communities over time at hydraulic retention times (HRTs) of 4-h, 8-h, and 16-h.

Drainage nutrient, dissolved gasses, and GHG flux samples were collected weekly from June to November. Nutrient samples were initially collected as grab samples at the influent sample pipe of each bioreactor, and then at one bioreactor in each block (Figure 1) once consistent influent concentrations were confirmed at all bioreactors. Outflow drainage samples were collected as grab samples from the Agridrain inline water control structure of each bioreactor throughout the sampling season. Greenhouse gas emissions from the surface of the bioreactors were measured using static vented chambers and processed on a gas chromatograph (SRI GC 8610).

A weighted nylon rope with eight bags of wood chips (whole or chopped) attached to the rope was deployed into each sampling well for multiple years of wood chip mass loss and microbial community analysis (Figure 2).

Results and Discussion

2016 was the first year of a multi-year study evaluating nutrient removal, dissolved gasses, and greenhouse gas (GHG) emissions at three HRTs (4, 8, and 16-h). The first year nutrient results indicate the highest mass load reduction at the lowest HRT (4-h), with a mean reduction of 55 grams NO_3-N per day. The observed reductions were 44 grams NO_3-N day^{-1} and 38 grams NO_3-N day^{-1} at 8-h and 16-h HRTs. Although the 4-h HRT resulted in the lowest percent removals of 10 percent, compared with 31 percent and 40 percent at 8-h and 16-h HRTs, respectively, mass load reduction was highest due to the increased flow volume treated. Drainage nutrient and GHG samples will be collected for this study in 2017, and wood chip analysis will continue through 2019.

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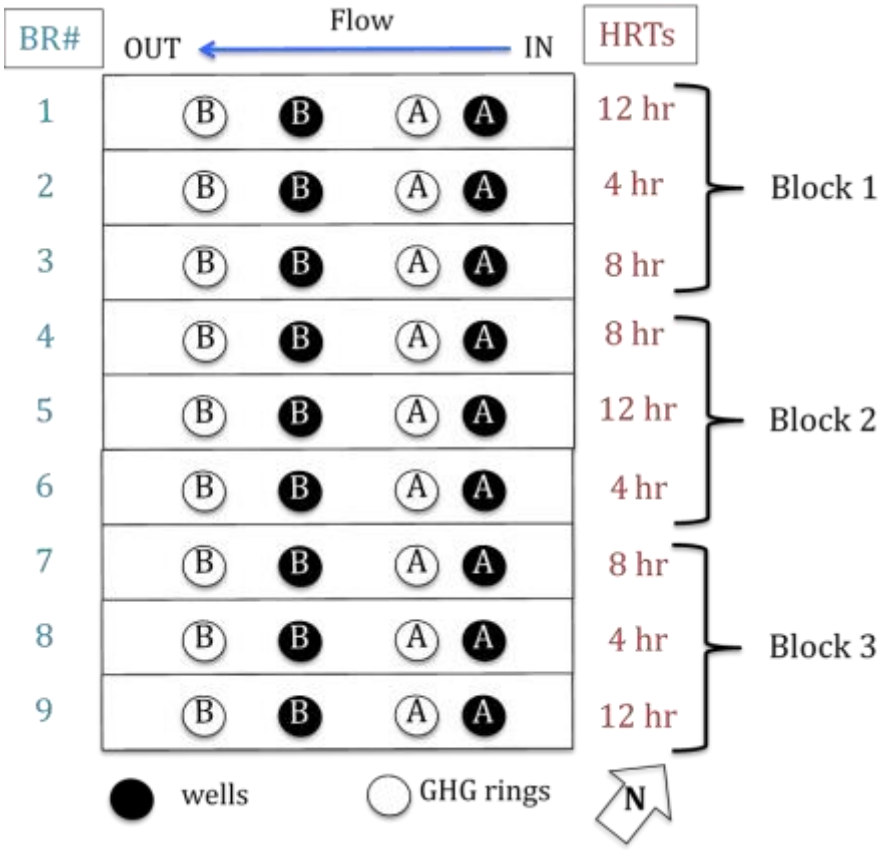

Figure 1. Pilot-scale bioreactors sampling schematic.

Figure 2. Wood chip sampling bag assembly image.