Pilot-Scale Bioreactor System for Replicated Field Research: Woodchip Evaluation and Corn Cob Refill

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Introduction

Bioreactors are being installed throughout Iowa to address the Iowa Nutrient Reduction Strategy's goals to achieve 41 percent nitrate reduction from non-point sources. Due to varying removal efficiencies reported for woodchip filled bioreactors, and the limited wood chip supply in Iowa, alternate fill materials should be evaluated. Multiple fill materials have been evaluated for nitrate removal potential in laboratory settings, and corn cobs have been shown to achieve high removal efficiencies. A concern with corn cob use in bioreactors is a potential increase in carbon released in drainage water.

Materials and Methods

Nine pilot-scale bioreactors were installed at the Ag Engineering/Agronomy Research Farm in 2014, with each bioreactor packed with woodchips. In 2018, three years of sample collection and evaluation of three replications of 2-h, 8-h, and 16-h HRTs (hydraulic retention times) in the pilot-scale bioreactor system were concluded. In 2016 and 2017, drainage nutrients and greenhouse gas (GHG) analysis were included. Tracer tests were conducted on the nine bioreactors in 2015 and 2018 to evaluate the flow characteristics. Push-pull studies were completed in 2018 for in-situ nitrate removal analysis. In fall 2018, six of the nine bioreactors were excavated (woodchips removed) and partially refilled with corn cobs. Excavation and refill plans are detailed in Figure 1. The sampling wells in the excavated portion of each bioreactor were removed for excavation and replaced. During excavation, multiple samples of woodchips from the bioreactors and corn cobs from the stockpile were collected for particle size analysis and additional evaluation.

Results and Discussion

The first replicated studies with each of the nine pilot-scale bioreactors filled with woodchips were concluded in 2018, with results to be published. Flow characteristics were evaluated in 2015 and again in 2018, demonstrating minimal change in the measured flow characteristics after three years of operation with tracer tests conducted at 2-h and 4-h HRTs. Preliminary analysis of the tracer tests is presented in Table 1. Ideal plug flow is indicated by a Morrill dispersion index (MDI) value of 1. Low MDI values suggest flow characteristics most similar to plug flow, and values of 22 or greater indicate completely mixed flow. Short circuiting values range from 0–1, with values closer to 1 indicating no short circuiting.

Preparation for the next phase of studies at the bioreactor system was completed in fall 2018, when six of the nine bioreactors were partially refilled with corn cobs (Figure 1). The excavated woodchips were carefully collected to analyze woodchip degradation and loss at various locations within bioreactors. Corn cobs are expected to release more carbon than the typical woodchip fill material, and strategic placement of the cobs at the inlet end should reduce the quantity of carbon exported from these systems.

Acknowledgements

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Table 1. Initial analysis of tracer tests conducted at nine pilot-scale bioreactors in spring 2015 and fall 2018. The values are the average results for all nine bioreactors during each test.

		Mean	StDev
MDI	Initial tracer (Spring 2015)	2.8	0.3
	Final tracer (Fall 2018)	3.3	0.4
Short circuiting	Initial tracer (Spring 2015)	0.73	0.03
	Final tracer (Fall 2018)	0.67	0.03

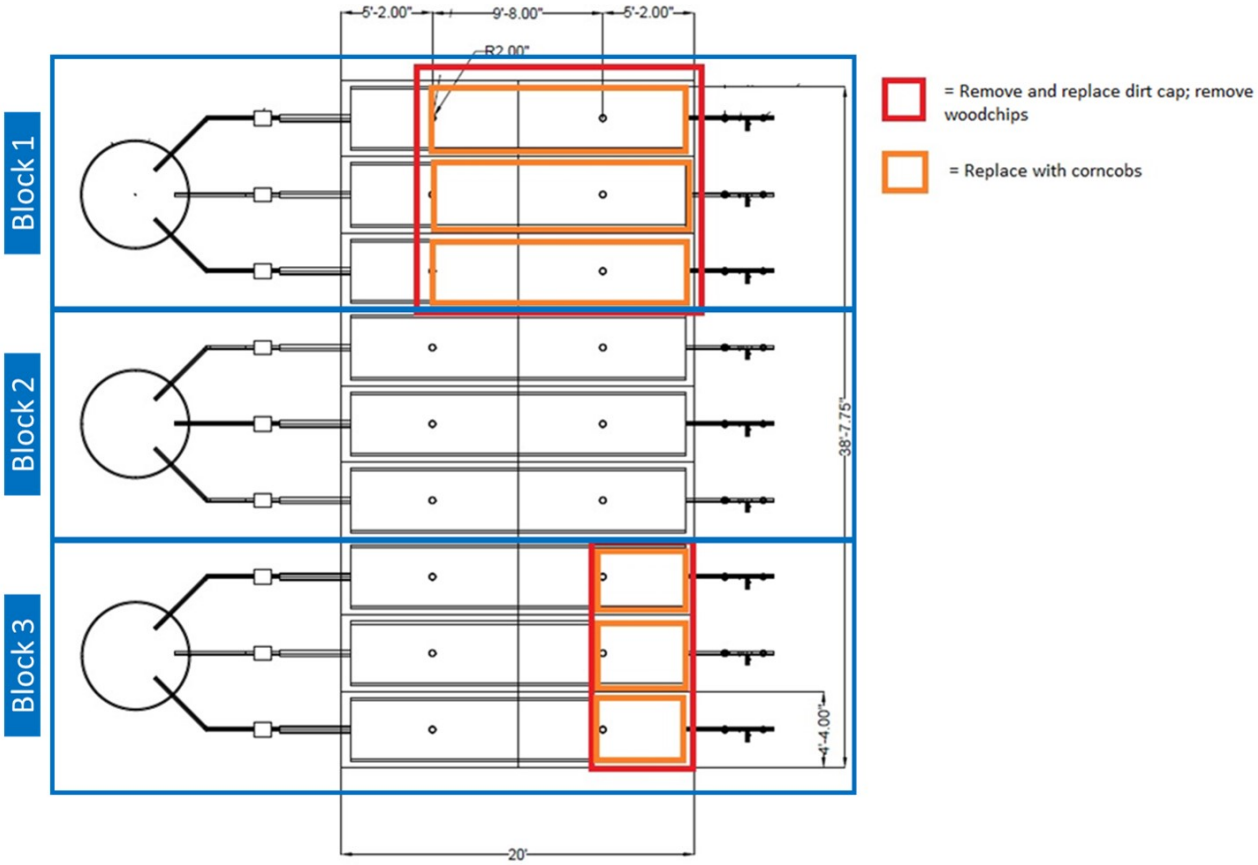

Figure 1. Schematic of the excavation and corn cob refill plan for the pilot-scale bioreactors. Block 2 was maintained as the woodchip filled control; block 1 was excavated to 3/4 the bioreactor length and refilled with corn cobs; block 3 was excavated to 1/4 bioreactor length and refilled with corn cobs.