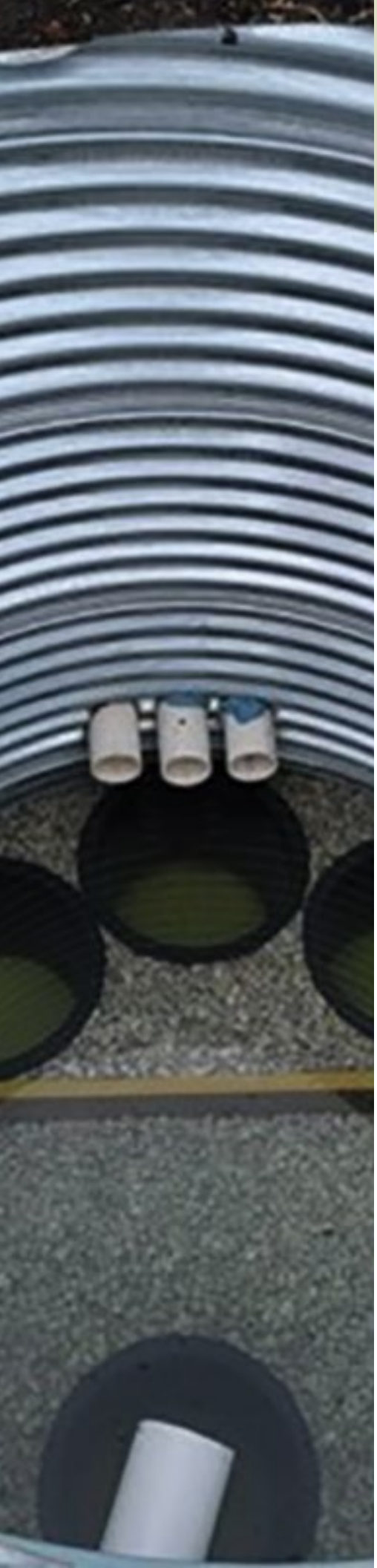

Dual-Chamber Bioreactor: Evaluation of Nitrate Removal Dynamics and Unintended Byproducts

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Denitrification bioreactors are one of several strategies being implemented to meet the Iowa Nutrient Reduction Strategy goal of reducing nonpoint source nitrogen by 41%. While this practice has been proven capable of reducing nitrate-nitrogen loads, less is understood about the spatial dynamics of the nitrate removal within the bioreactors or the potential for unintended byproducts to form. To ensure the long-term sustainability of this practice, the removal dynamics and potential for alternative byproducts to form should be evaluated.

Materials and Methods

The dual-chamber bioreactor was installed at the Iowa State University Uthe Farm, a Committee for Agricultural Development (CAD) farm, in the summer of 2018. This bioreactor consists of two woodchip bioreactor chambers connected in parallel with nine randomly located sampling wells per bioreactor chamber. There are also five water control structures for this bioreactor (a main inlet to direct the flow into the bioreactor chambers, a structure at the inlet of each bioreactor chamber as well as at the outlet of each chamber).

Water quality samples have been collected weekly at this site from the 18 sampling wells and the five water control structures since 2019 while tile drainage is flowing. These water quality samples are analyzed in the Water Quality Research Lab at Iowa State University for nitrate-N, E. coli, and total organic carbon (TOC). At the site, the temperature, dissolved oxygen, and water level in the bioreactor are measured at each sampling location.

In 2021, additional water quality monitoring was added. This additional monitoring consists of sample collection for sulfate, dissolved methane gas, dissolved nitrous oxide gas, and pH. These water quality samples are collected weekly from all sampling locations.

Results and Discussion

The dual-chamber bioreactor has consistently experienced lower-than-anticipated flow conditions from 2019 to 2021. Due to the low flow conditions in the bioreactor chambers, extremely high nitrate removal often has been observed. With the high nitrate removal in the bioreactor, sulfate reduction was documented in 2021. Average total organic carbon levels have decreased each year throughout the first three years of operation. The spatial dynamics of the nitrate removal, sulfate reduction, and TOC will be evaluated.

Due to the lower-than-expected flow conditions at this site, USDA-NRCS has approved the addition of a pumping system to the bioreactor. This pumping system is to be installed in 2022 to supplement the flow entering the bioreactor. Water will be pumped from the nearby Big Creek, which has been approved by the Iowa DNR (Water Use Permit No. 10639). Monitoring of this pumping system will begin after installation. The water quality monitoring will remain the same as in 2021.

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