Denitrifying Woodchip Bioreactors: wood particle treatment systems for removing nitrogen from production water

What are woodchip bioreactors?

Denitrifiying woodchip bioreactors are treatment systems that use filtering and microbial action to remove contaminants or nutrients from water. Wood particle and/or peat-based bioreactors are a relatively new technology for the removal of nitrate-nitrogen from a variety of runoff waters. Some systems are also capable of removing phosphorus and a range of microbial contaminants, including plant pathogens. Wood/peat based bioreactors have now been field-tested for nearly a decade in several agricultural applications across Ontario, including treatment of greenhouse process water.

The wood-based media provides a carbon source for microorganisms carrying out a conversion of nitrate-nitrogen to nitrogen gas (denitrification) under anaerobic conditions. The media may be enclosed in a tank, or in an in-ground pit (lined if not in clay soils). In a down-flow system, the water to be treated is distributed to the top of the bioreactor unit through perforated pipes. Water percolates down through the media, and is collected by perforated piping, and forced up and out of the filter by hydrostatic pressure when the next pulse of water to be treated is applied to the top of the system (Figure 1). Stages of construction of a down-flow bioreactor are shown in Figure 2. In up-flow designs, water is pumped to the bottom of the unit and forced upwards.

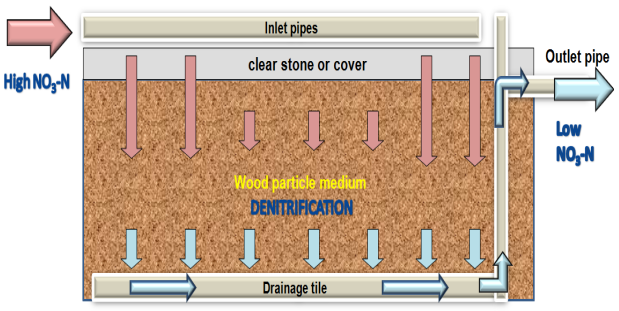

Figure 1: Design of a gravity-fed in-ground bioreactor

The effectiveness of treatment is governed by a number of factors including: hydraulic retention time, temperature, pH, input nitrate levels and water quality, consistency of flow, and age of the wood-based media. For proper operation and prolonged media life, the system must remain water-saturated.

The level of nitrate removal depends on a combination of temperature and retention time (residence time of the water in the system). Because this is a biological process, removal rates are reduced at lower temperatures. Since irrigation water volumes in ornamental production systems are typically lower in the cooler months, longer residence times can be implemented. This makes it a functional treatment system for Ontario conditions. In-ground or enclosed systems will have more buffered temperature ranges. Sizing the treatment system to balance hydraulic retention time and nitrate-nitrogen concentrations is important: under-sizing results in insufficient nitrate reduction while over-sizing results in sulfate reduction and the production of hydrogen sulphide.

Since this is a biological system, the treated water may have a high biological oxygen demand (BOD) as it exits the system. Further treatment such as an aerobic polishing filter may be used to reduce BOD if required prior to reuse.

Who might use a woodchip bioreactor?

- A grower with a limited land base who needs to remove nitrogen before reuse or disposal
- The system is particularly suitable for growers who have low pre-treatment phosphorus levels in their water or are not concerned about phosphorus removal
- The system is particularly effective placed in-line before a storage pond or silo that can be aerated

- Bioreactors can be sized to meet the needs of both small and large growers
- Bioreactors will work best for growers who produce consistent volumes of water for treatment or can pump from a collection pond or have other means of flow balancing
- For operations with high nitrate water and located on sandy soils or shallow aquifers, a completely contained system (storage & treatment) will not impact groundwater
- For growers that discharge to a municipal sewer system, reduction in nitrogen levels may be a pre-requisite to discharge
- These systems are less effective at treating water with high solid and organic matter content that may cause the system to clog. A prefilter to remove particulate matter will improve performance.

Consult a firm familiar with proper design and construction of these bioreactors. Note that discharges to the environment require an Environmental Compliance Approval.

Further Reading

Robertson, W. D., Merkley, L. C., 2009. In-stream bioreactor for agricultural nitrate treatment. Journal of Environmental Quality, 38(1): 230-237.

Woodchip Bioreactors for Nitrate in Agricultural Drainage, Christianson and Helmers, Iowa State University Extension and Outreach website PMR1008.pdf

Denitrifying bioreactors: An emerging best management practice to improve water quality, Lassiter and Easton, Virginia Tech Cooperative Extension Publication BSE-55P https://pubs.ext.vt.edu/BSE/BSE-55/BSE-55-PDF.pdf

Figure 2. Construction stages of a gravity-fed bioreactor.

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