United States Department of Agriculture

Natural Resources Conservation Service

CONSERVATION PRACTICE STANDARD

DENITRIFYING BIOREACTOR

CODE 605

(no)

DEFINITION

A structure that uses a carbon source to reduce the concentration of nitrate nitrogen in subsurface agricultural drainage flow through enhanced denitrification.

PURPOSE

This practice is used to achieve the following purpose:

- Improve water quality by reducing the concentration of nitrate nitrogen in flow from subsurface agricultural drainage systems

CONDITIONS WHERE PRACTICE APPLIES

This practice applies to sites where there is a need to reduce the concentration of nitrate nitrogen in the flow from subsurface drainage systems.

This practice does not apply to underground outlets from practices, such as terraces, where the drainage source is primarily from surface inlets.

CRITERIA

General Criteria Applicable to All Purposes

Performance and capacity

Design the bioreactor to meet one of the following criteria:

- Provide capacity to treat at least 15 percent of the peak flow from the drainage system. Disregard flow from surface inlets when calculating design subsurface drain flow for capacity purposes. Design the bioreactor hydraulic retention time for a minimum of 3 hours at the peak flow capacity. Account for the porosity of the media and use the average depth of flow through the media.
- Design capacity, hydraulic retention time, and nitrate removal performance to achieve an overall 20 percent nitrate reduction from the average annual flow of the subsurface drainage system, taking into account bioreactor-treated flow and bypass flow.

Media chamber

Design the bioreactor carbon media for an expected life of at least 10 years. Select carbon media that are relatively coarse, have a low percentage of fines, have a low content of soil or other contaminants, and that will be durable enough to last for 10 years or can be removed and replaced, as needed. Before placing the carbon media in the chamber, line the walls and floor with a geotextile or plastic membrane to prevent migration of soil into the chamber.

The most commonly used carbon media is wood chips. Use the following criteria when selecting wood chips:

- Wood species with low tannin content
- Ninety percent of chips are 1 to 2 inches in length
- Do not use rot-resistant woods such as cedar or redwood
- Do not use wood that has been painted or treated for rot resistance
- Do not use chips that contain significant amounts of sawdust, leaf litter, bark, or soil

Design the media chamber to prevent development of preferential flow paths by distributing inflow across the entire width of the chamber. For chambers with a length to width ratio wider than 4:1, use a multiple-header distribution system so the width served by each header is no greater than 25 percent of the chamber length.

Water control structures
Design the bioreactor inlet and outlet water control structures to provide the required capacity and hydraulic retention time. Use the criteria in NRCS Conservation Practice Standard (CPS) Structure for Water Control (Code 587) to design the water control structures.

Set the elevation of the upstream water control structure to prevent damage to upslope crops from an elevated water table. If the topography is such that the planned water table upstream of the bioreactor will negatively affect crop performance, manage water levels at the upstream end of the bioreactor using the criteria in NRCS CPS Drainage Water Management (Code 554).

Design the water control structure to safely bypass flows in excess of the design capacity. Include a low-level orifice in the outlet water control structure to assure the media chamber drains in a maximum of 48 hours during periods of low or no flow. In addition, provide an outlet to completely drain the media chamber to facilitate operation and maintenance.

Protection
To minimize interference with cropping, locate the bioreactor far enough away from crop fields to allow field equipment to operate without driving over the bioreactor chamber and at an elevation to allow proper drainage of crop fields. To ensure that the carbon media is not compacted by equipment driving over it, provide signage and/or fencing to prevent damage.

Grade the area around the reactor to divert surface runoff away from the reactor and ensure that water does not pond around the reactor. Use the criteria in NRCS CPS Critical Area Planting (Code 342) to protect all noncrop areas disturbed by construction with seeding or mulching as soon as possible after construction. For denitrifying bioreactors installed in existing filter strips or other conservation practices, revegetate disturbed areas according to the seeding requirements of the conservation practice disturbed by construction.

CONSIDERATIONS

When planning, designing, and installing this practice, consider—

- Denitrifying bioreactors can work effectively with other practices and management systems to achieve further reductions in nitrate nitrogen levels leaving crop fields. Examples include—
  - NRCS CPS Nutrient Management (Code 590),
  - NRCS CPS Cover Crop (Code 340), and
  - NRCS CPS Drainage Water Management (Code 554).
- Determining the normal nitrate levels in the subsurface drain discharge water prior to design work will help to establish design parameters. This information will also be helpful in any monitoring that occurs after installation.
- Bioreactors work by supporting colonies of bacteria on the carbon media. Inoculating the media during installation will hasten the startup process. Inoculation can be as simple as adding carbon media and effluent from an existing bioreactor.

- Piping in the reactor can become clogged over time. Consider including vertical cleanout pipes to allow for “jetting out” any clogged pipes.
- It is important to maintain porosity in the carbon media to ensure that water flows evenly through the media and does not short circuit the system. Mixing gravel with the required amount of carbon media can help maintain the necessary porosity.
- During startup, the flow from a denitrifying bioreactor can contain leached organics and some plant nutrients. It may be necessary to take actions to mitigate any harmful effects if flow from the reactor goes directly into a stream or other water body.
- Denitirfying bioreactors can provide benefits year around, not just during the cropping season. Therefore, if planned water elevations will not negatively affect crops or field operations, maintain design water elevations throughout the year.
- When revegetating areas disturbed by construction, consider including plant species that support pollinators and other beneficial insects.

PLANS AND SPECIFICATIONS

Develop plans and specifications for the denitrifying bioreactor that describe the requirements for applying the practice to achieve its intended purpose. The plans and specifications must be site-specific and as a minimum include—

- A plan view of the layout of the denitrifying bioreactor and associated components.
- Typical cross sections of the bioreactor.
- Profiles of the bioreactor, including inlets and outlets.
- Details of required structures for water level control.
- Material specifications for the bioreactor media.
- Seeding requirements, if needed.
- Construction specifications that describe in writing the site-specific installation requirements of the bioreactor and associated components.

OPERATION AND MAINTENANCE

Provide an operation and maintenance plan and review this with the land manager. Specified actions should include normal repetitive activities in the application and use of the practice, along with repair and upkeep of the practice. The plan must be site-specific and as a minimum include—

- Planned water level management and timing.
- Inspection and maintenance requirements of the bioreactor and contributing drainage system, especially upstream surface inlets.
- Requirements for periodic monitoring of the bioreactor media and replacement or replenishment of media as needed.
- Any required monitoring and reporting criteria.

REFERENCES

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