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 via enhanced denitrification.

PURPOSE

This practice is applied to achieve the following purpose:

- Improve water quality by reducing the nitrate nitrogen content of subsurface agricultural drainage flow.

CONDITIONS WHERE PRACTICE APPLIES

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

This practice does not apply to underground outlets with surface intakes.

CRITERIA

General Criteria Applicable to All Purposes

Performance and Capacity. Design the capacity of the bioreactor based on one of the following:

- Treat peak flow from a 10-year, 24-hour drain flow event.
- Treat at least 15 percent of the peak flow from the drainage system.
- Treat at least 60 percent of the long-term average annual flow from the drainage system using locally proven criteria (e.g., drainage coefficient).

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. The effective volume of the reactor is calculated as:

$$V = L \times W \times (d_{in} + d_{out})/2 \times P$$

Where:

V = effective volume of media (ft^3)
L and W are the length and width of media chamber (feet)
d_{in} and d_{out} are the depth of the inlet water and outlet water (feet)
P is the porosity of the material (decimal percentage)

Design the bioreactor to achieve at least a 30-percent annual reduction in the nitrate nitrogen load of the water flowing through the bioreactor.

If reducing conditions may result in the production of methyl mercury, make additional provisions to ensure that stagnant conditions do not develop in the media chamber.

Media Chamber. Use a medium for the carbon source that is reasonably free from dirt, fines, and other contaminants. Distribute the media within the bioreactor to achieve a uniform flow path.

Use a plastic lining for the bottom and sides of the bioreactor to prevent migration of soil particles into the bioreactor and minimize bypass of treatment flow by leaching from the media chamber. However, if the bioreactor is located in glacial till soil and has a Unified Soil Classification System designation of CL or CH, the plastic liner is not required unless sand is encountered during the site investigation or during construction.

If a soil cap is to be constructed over the top of the chamber, use geotextile to separate the media from the soil. Geotextile must be non-woven, class II, and meet the requirements of Iowa Construction Specification IA-95, Geotextile.

Design the bioreactor media for an expected life of at least 10 years. To create a longer lifespan, provide provisions for periodic renewal of the media.

Design the media chamber to prevent development of preferential flow pattern. For a media chamber with a length to width ratio of 4:1 or greater, use a perforated distribution pipe at the chamber inlet and a perforated collection pipe at the chamber outlet. For wider chambers, design a multiple-header distribution system so that the width served by each header is no greater than 25 percent of the chamber length.

Mound the media in the chamber to allow for settlement of the media and to shed water. The media at the center of the trench shall be mounded a minimum of 10 percent of the total depth of the media material.

Specify the carbon media that goes in the chamber. If wood chips are the media, specifically note that no high tannin content wood such as oak, cedar or redwood are to be used. Do not use any wood that has been treated for ground contact.

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 Structure for Water Control (587), for the design.

Select or design water control structures that control the upstream water elevation and provide safe bypass of flows in excess of the design capacity.

Select a design water surface elevation at the upstream water control structure that will prevent upslope crop damage from an elevated water table.

Provide a low elevation orifice or opening of some type on the outlet structure to assure the media chamber drains in a maximum of 48 hours during periods of no-drain flow.

Provide an outlet that will completely drain the media chamber to facilitate bioreactor management and maintenance.

Protection. Protect the bioreactor from intermittent surface storm flows that could result in flushing out of the established biofilm.

Construct the ground surface above the bioreactor to shed water and to allow for settlement. Dispose of excess soil excavated during the installation of the bioreactor by blending with the adjacent landscape or hauling away.

To prevent compaction of the bioreactor media, identify the bioreactor location with appropriate signage or fence the site to avoid equipment travel over the bioreactor. If there will be equipment traffic for mowing or other purposes, provide adequate cover to prevent damage to the bioreactor.

During release of tile drainage water from the water control structures, flow velocity in the tile lines must not exceed the maximum velocity prescribed by Subsurface Drain (606).

Protect all disturbed non-crop construction areas by seeding or mulching within 14 days of construction. See Critical Area Planting (342) for criteria on seed selection, seedbed preparation, fertilizing, and seeding. For installation of the denitrifying bioreactor in an existing filter strip or other conservation practice, revegetate disturbed areas according to the seeding requirements of the conservation practice disturbed by construction.

CONSIDERATIONS

Other practices and management systems can achieve a reduction of nitrate nitrogen levels separately or in conjunction with the denitrifying bioreactor. Examples include Nutrient Management (590); Cover Crop (340); and Drainage Water Management (554).

Determining the normal nitrate levels expected in the tile discharge water prior to design work will aid in establishing design parameters.

Add inoculants to improve the function of the bioreactor.

Mix inert materials such as gravel with the required amount of reactive carbon source to provide the required bioreactor volume, porosity, and flow rate.

Situating the bioreactor on a low bench will minimize interference with the drainage needs of the area served during the growing season.

Exclude surface water from the bioreactor as much as possible by selecting a location away from areas that will pond surface water during storm events.

When designing the bioreactor using methods based on a percentage of the peak flow from the drainage system, target 15 to 20 percent of peak flow for best performance.

Be aware of the effects on downstream flows or aquifers that would affect other water uses or users. For example, the initial flow from the bioreactor at start up may contain undesired contaminants.

If site topography is such that planned elevated water table upstream of the bioreactor might negatively affect crop performance, manage water levels at the upstream end of the bioreactor according to criteria in Drainage Water Management (554).

Maintain the design water elevations throughout the year if an elevated water table upstream of the bioreactor will not negatively affect crops.

PLANS AND SPECIFICATIONS

Develop plans and specifications for the denitrifying bioreactor that describe the requirements for applying the practice to achieve its intended purpose.

As a minimum, the plans and specifications must include:

- A plan view of the layout of the denitrifying bioreactor and associated components;
- Typical cross section(s) of the bioreactor;
- Profile(s) of the bioreactor including inlet(s) and outlet(s);
- Details of required structures for water level control;
- Material specifications for the bioreactor media;
- Seeding requirements, if needed.

The following list of Construction Specifications is intended as a guide to selecting the appropriate specifications for each specific project. The list includes most, but may not contain all, of the specifications needed for a specific project:

- IA-5 Pollution Control
- IA-6 Seeding and Mulching for Protective Cover
- IA-21 Excavation
- IA-605 Denitrifying Bioreactor

OPERATION AND MAINTENANCE

Provide an operation and management (O&M) 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 include, but not be limited to, a description of the following:

- Planned water level management and timing.
- Inspection and maintenance requirements of the bioreactor and contributing drainage system.
- Requirements for monitoring the status of the bioreactor media and replacement/replenishment of media as needed.
- Monitoring and reporting criteria that demonstrate system performance.
- Monitoring information to improve the design and management of this practice as needed.

REFERENCES

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