NATURAL RESOURCES CONSERVATION SERVICE

CONSERVATION PRACTICE STANDARD

DENITRIFYING BIOREACTOR

(Ac.)

INTERIM CODE 747

DEFINITION

A structure containing a carbon source, installed to reduce the concentration of nitrate nitrogen in surface or subsurface agricultural drainage flow via enhanced denitrification.

PURPOSE

To improve water quality by reducing the nitrate-nitrogen content of surface or subsurface agricultural drainage flow.

CONDITIONS WHERE PRACTICE APPLIES

This practice applies to sites where:

- there is a need to reduce the concentration of nitrate-nitrogen of surface or subsurface drainage flow.

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

CRITERIA

Performance and Capacity

Design the bioreactor to achieve at least 30% reduction in the nitrate-nitrogen concentration of the water flowing through the bioreactor. Limit the planned nitrate-nitrogen reduction performance to 85% maximum, unless additional provisions are made to prevent extremely reducing conditions that would result in the production of methyl mercury.

Provide a hydraulic retention time through the bioreactor sufficient to achieve the planned reduction in nitrate-nitrogen concentration at the design flow rate.

Determine the bioreactor size and configuration using design procedures based on the design flow rate, permeability of the carbon source, and the desired hydraulic retention time.

For bioreactors that treat subsurface tile drain flow, design the capacity of the bioreactor to treat the water from a 10-year, 24-hour drain flow event, or 10-20% of the peak capacity of the drainage system. Flow from surface inlets may be disregarded when calculating design subsurface drain flow.

For bioreactors that treat surface flow, ensure that the design will prevent excessive sedimentation from clogging the bioreactor, through pretreatment of the flow or other means.

Media Chamber

Use a medium for the carbon source that is reasonably free from dirt, fines, and other contaminants.

Use geotextile or plastic lining for the bottom, sides, and top of the bioreactor as needed to prevent the migration of soil particles into the bioreactor, based on the soils and geology of the site.

Ensure that the media chamber is completely drained during times of low flow, to prevent stagnant conditions in the bioreactor.

Design the bioreactor for an expected life of at least 10 years unless provisions are made for periodic renewal.

Water Control Structures

For bioreactors that treat subsurface tile drain flow , design water control structures to maintain the water level at the upstream end of the bioreactor as high as practical while meeting the drainage needs in the area served by the system.

Manage the water level at the upstream end of

the bioreactor according to the criteria of Conservation Practice Standard 554 – Drainage Water Management, if the topography of the site is such that the planned elevated water table upstream of the bioreactor will negatively affect crop drainage.

See Structure for Water Control (587) for criteria to design water control structures.

Provide a means to evenly distribute and collect water in the upstream and downstream ends of the media chamber.

Provide a means to completely drain the media chamber and to facilitate management and maintenance of the bioreactor.

Protection

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

Construct the surface of the bioreactor to shed water from the top of the bioreactor and to allow for settlement. Excess soil removed during the installation of the bioreactor should be disposed of by blending with the adjacent landscape or hauling away.

For safety and 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. Alternatively, if the bioreactor is expected to be subject to equipment traffic for mowing or other purposes, ensure that the design provides adequate cover to prevent damage to the bioreactor, based on soil bearing strength.

When tile drainage water is released from the water control structures, drainage water flow velocity in the tile lines must not exceed velocity prescribed by Conservation Practice Standard 606 (Subsurface Drain).

Protect from erosion all non-crop areas disturbed by construction by seeding or mulching within 14 days of construction. See Critical Area Planting (342) for criteria on seed selection, seedbed preparation, fertilizing, and seeding, and Mulching (484) for criteria on mulching.

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).

Avoid a continually saturated zone with low or zero flow rate (stagnant zone) that may lead to production of contaminants such as methyl mercury.

Inoculants may be added to improve the function of the bioreactor. Inert materials such as gravel may be mixed with the carbon source to provide the required bioreactor volume and flow rate along with the required amount of reactive carbon.

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

PLANS AND SPECIFICATIONS

Plans and specifications for denitrifying bioreactor shall be in keeping with this standard and shall 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
- Seeding requirements, if needed
- Construction specifications that describe site specific installation requirements of the denitrifying bioreactor and associated components

OPERATION AND MAINTENANCE

An operation and management (O&M) plan must be provided to and reviewed 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, especially upstream surface inlets
- Requirements for monitoring status of the bioreactor media and replacement/ replenishment of media as needed.
- Monitoring and reporting designed to demonstrate system performance and provide information to improve the design and management of this practice, if available.

REFERENCES

Christianson, L. E., A. Bhandari, M.H. Helmers, and M. St. Clair. 2009. Denitrifying Bioreactors for Treatment of Tile Drainage. *In*: Proceedings of World Environmental and Water Resources Congress, May 17-21, 2009

Cooke, R.A. and N.L. Bell. 2012. Protocol and Interactive Routine for the Design of Subsurface Bioreactors. *Submitted to*: Applied Engineering In Agriculture, August, 2012.