Demonstrating the Nitrate-Nitrogen – Removal Effectiveness of Denitrifying Bioreactors in South Dakota for Improved Drainage Water management

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The issue and one of the solutions

Excess usage of nitrogen fertilizer on crop land and subsurface (tile) drainage of water may lead to nitrate exports to natural aquatic ecosystems. Excess loading of nitrogen contributes to hypoxic conditions in natural aquatic systems. To reduce the nitrate load, the water can be treated before it exits the drainage system. Woodchip bioreactors are one option of a cost effective, simple edge-of-field technology to reduce the nitrate load. In these bioreactors the drain water is routed through a trench in the ground filled with woodchips. Denitrifying bacteria colonizing the woodchips under anaerobic conditions convert nitrate to inert nitrogen gas.

Objectives

1. Demonstrate and evaluate field scale bioreactor designs by installing, monitoring, analyzing and documenting their effectiveness for removing nitrate from subsurface drainage water in SD.
2. Estimate the cost of nitrate removed from the tile water per treatment area per year.

Methodology

Bioreactor design criteria:

The design method is optimized for nitrate removal capacity and cost efficiency .

Design flow rate:

Bioreactor is designed to treat 10-20% of the anticipated peak flow rate. Drainage control structures are used to control water flow through the bioreactor.

Design retention time:

The optimum retention time is 4-8 hrs. Shorter retention time cause insufficient time to biologically remove the dissolved oxygen and the nitrate-nitrogen from the drain water. Longer retention time may cause reduction of sulfur and emission of unwanted gases such as H_2S or mobilization of methyl mercury from the bioreactor.

The bioreactor installation process

1. Excavating the trench about 21 ft. wide, 130 ft. long and 5 ft. deep for the bioreactor.

2. Woodchips used as a carbon source for denitrifying bacteria in the bioreactor.

3. Filling the lined trench with woodchips. Perforated PVC distribution/collector manifolds were placed at both ends.

4. Covering the woodchips with a geo-textile fabric to prevent the woodchips from being contaminated by the soil.

5. Installing the drainage control structure used to divert water through the trench.

6. Completing the installation by backfilling the topsoil .

Water sampling and analysis

Sampling of water twice per week in both upstream and downstream control structure.

Nitrate concentration and TKN was determined using a spectrophotometer (DR 2800).

Estimation of cost of nitrate removal

Cost detail for Baltic site bioreactor installation

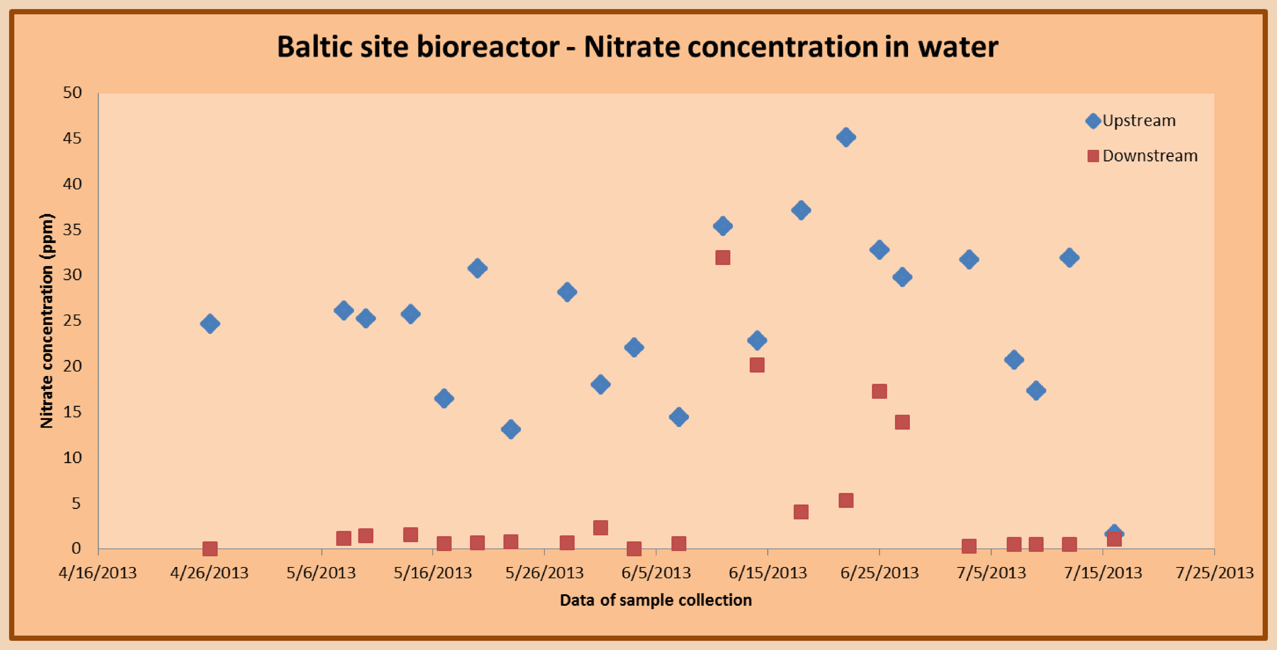
Cost category	Cost ($)	Replacement year	Cost per year ($)
Excavation and backfilling	1,900	20	95
Woodchips	3925	20	196
Plastic liner	500	20	25
Control structure	1675	40	42
Other (personnel transport, labor)	1000	40	25
Stop logs	14	8	2

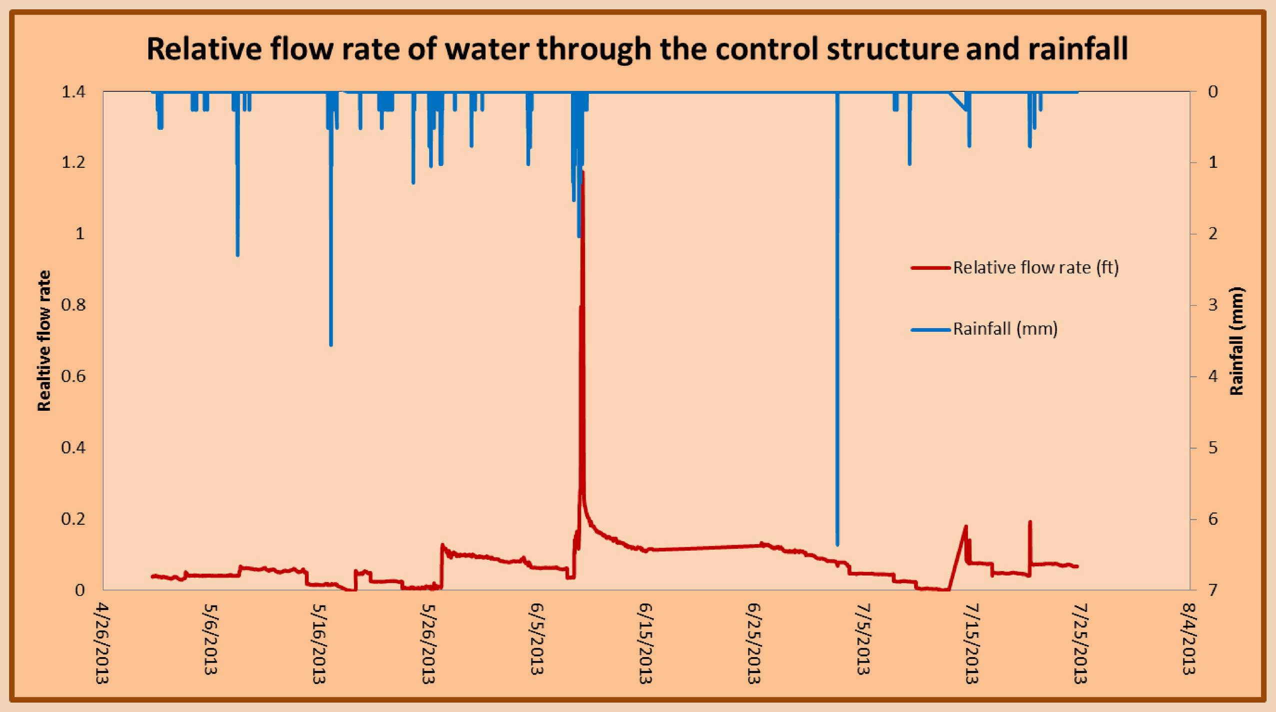
Total cost per one year $ 385

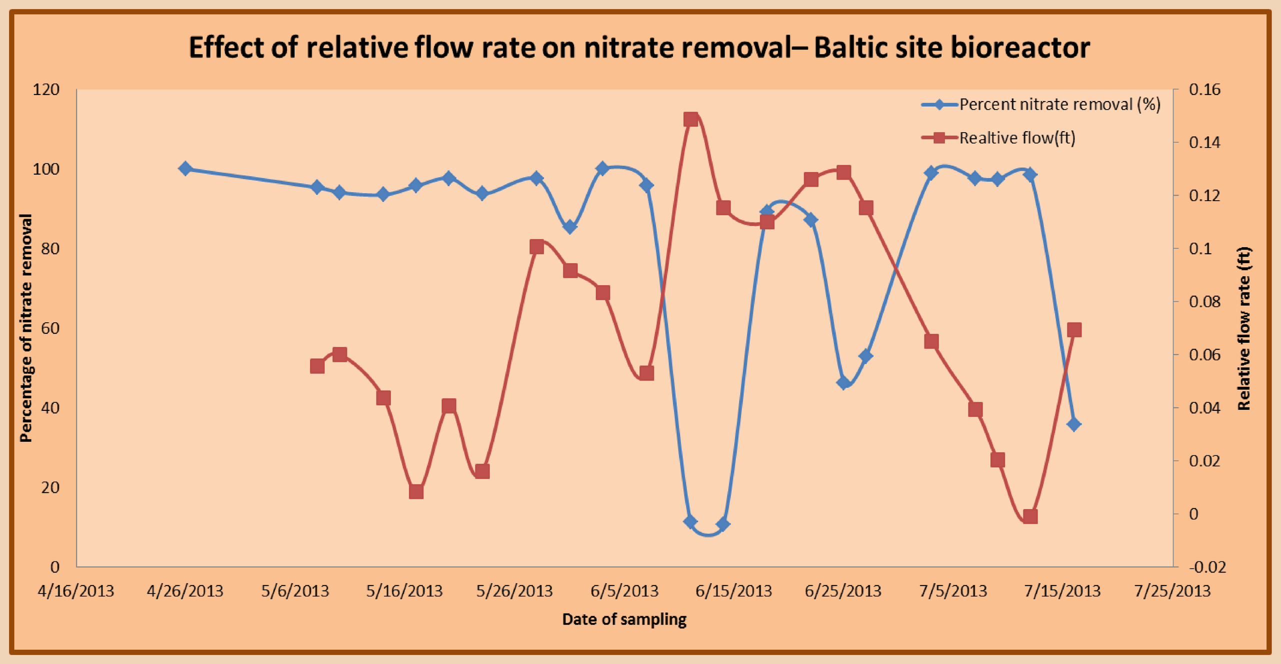
Total drained area 16.2 ha

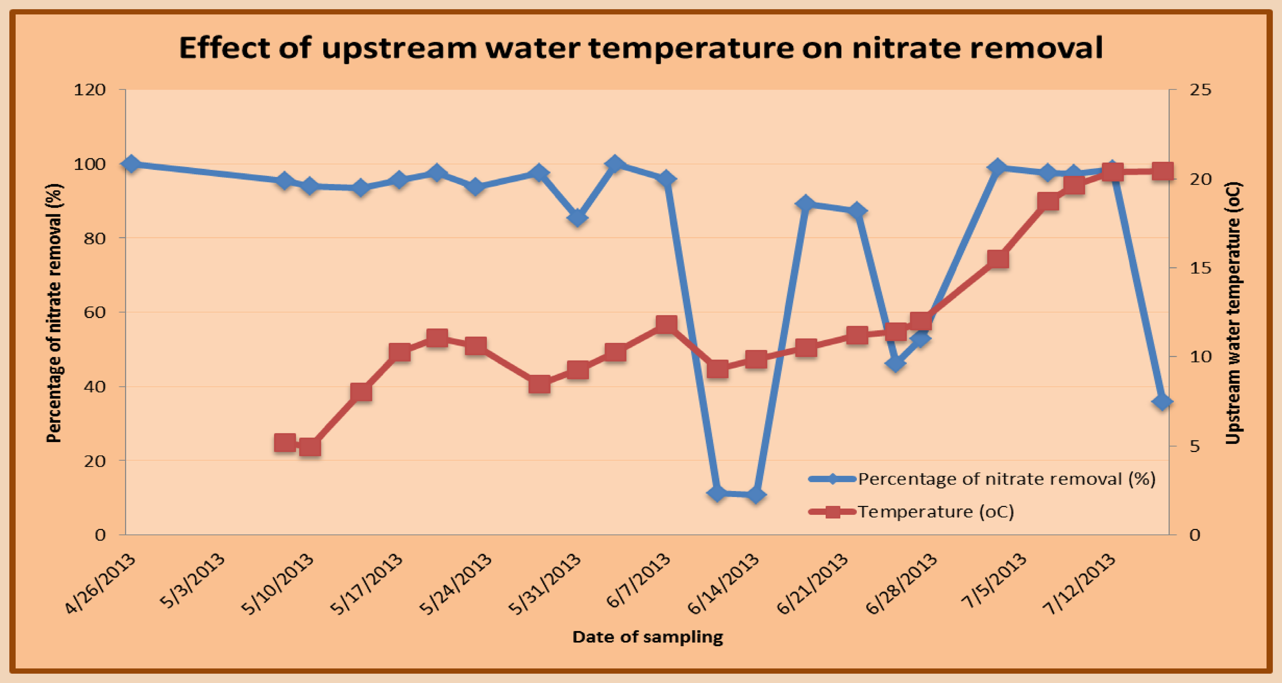
Cost per treatment area $ 24 /year/ha

Results and discussion









Conclusion

Woodchip bioreactors serve as a cost effective nitrate removal technology to remove the nitrate from the subsurface drainage water in SD.

References

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