Saturated Buffers for South Dakota

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Overview

Nitrogen (N) is essential for crop growth, but too much of it in the form of nitrate-N is a public health concern if used for human consumption and may cause algae growth in surface water. One source of nitrate-N losses from cropland is through subsurface (tile) drainage. Saturated buffers are a relatively new but effective tool for removing soluble nitrate-nitrogen from subsurface (tile) drainage before the tile discharge flows into a surface waterway. A saturated buffer has two elements: a perennially-vegetated filter strip and a raised shallow water table (Figure 1). Filter strips are typically located next to crop ground immediately adjacent and parallel to streams, wetlands, lakes, or other permanent water bodies. Filter strips have traditionally have been used to slow and filter surface runoff from the adjacent crop ground. However, by artificially raising the water table along the buffer, we add the capability of directly absorbing water and nutrients from the tile drainage through plant uptake and increasing denitrification, cycling nitrate-N into harmless, di-nitrogen gas which is returned to the atmosphere.

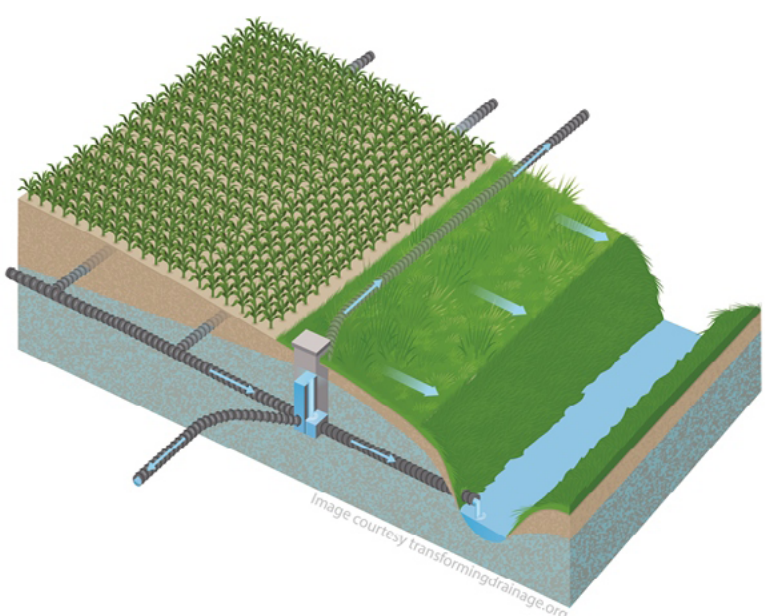

Figure 1. Model of a saturated buffer. (Source: Adapted from, “Drainage Water Storage for Improved Resiliency and Environmental Performance of Agricultural Landscapes” by Reinhart et al.)

How They Work

To raise the water table, a control structure diverts a fraction of the tile drainage water flow into perforated lateral lines that are placed parallel to the stream and beneath the filter strip, and releases that fraction into the buffer as shallow groundwater. The saturated buffer can then reduce the nitrate concentration and load through (1) direct uptake of nitrogen by the vegetation in the buffer, (2) converting nitrate-nitrogen into harmless nitrogen gas (N_2) that is released back into the atmosphere (denitrification), and (3) reducing the water volume (load) entering the stream through water uptake by the vegetation. Control structures can be added to new or existing drainage systems to redirect drain flow through the buffer.

Site Requirements and Design

In general, a saturated buffer will function best if the buffer is at least 30 feet wide with enough tile-drained area (at least 15 acres per recommendation from NRCS Conservation Practice Standard 604) to provide sufficient flow. Saturated buffers are dependent on specific soil properties, and a site investigation is recommended to determine if the practice can be applied and be effective. Banks should not be too high or steep, since changes to the water content in the stream bank could increase risk of bank failure. In general, banks less than eight feet in height is considered acceptable. A loam soil is recommended for best performance. A clay soil may not allow enough water movement through the buffer, and a sandy soil will allow too much. Vegetation such as perennial grasses, shrubs, and trees can all be used in a saturated buffer to promote plant uptake of nitrogen and provide wildlife habitat. However, woody species should be planted far enough away from the distribution line to prevent root plugging. Buffer soils should contain at least 1.2% organic matter in the top 2.5 feet of soil to ensure sufficient carbon for denitrification. Unlike controlled drainage, which is most effective with a flat field, saturated buffers do not have slope restrictions on the field they are draining. There should be some drop from the field to the buffer so water is not held back in the field as it moves through the buffer.

Research and demonstration site performance

During the summer of 2016, staff from the SDSU Department of Agricultural and Biosystems Engineering and the SD Water Resources Institute installed two field-scale saturated buffer systems near Baltic, SD and Flandreau, SD. The systems were monitored to determine the buffers' nitrate removal effectiveness from tile drainage water and showed nitrate concentration reduction rates ranging from 65-95% (Sharma, 2018). The costs for materials including control structure and pipe, and installation of these buffers were between $2,000 and $2,500. Assuming similar performance and a 20 year lifespan, the cost was between $0.06 and $1.00 per pound of nitrate removed. The difference in cost was because one saturated buffer received a higher nitrate load than the other one. Receiving and treating a higher nitrate load led to a reduced cost per pound. Multiple saturated buffers can perform similarly and have similar fixed installation and maintenance costs, but if the amount of nitrate coming into one is lower than the other, then the cost to treat each pound of nitrate will be higher. A separate study from 15 saturated buffers across four states determined an average cost of removal as $1.00, so results from the South Dakota were similar to what has been observed elsewhere. The buffers were not as effective during higher flows because water moved through the buffer too quickly which limited plant uptake and denitrification. Since nitrate removal depends on active microbes, saturated buffers are also not as effective when temperatures are below 40°F and microbial activity is limited.

Benefits

Saturated buffers are a low maintenance conservation drainage option that can improve water quality through nutrient concentration and flow volume reductions, while providing wildlife habitat. When ideal conditions are met, nitrate removal rates close to 100% have been reported, indicative of the potential benefit of saturated buffers to watersheds dominated by agricultural fields with subsurface drainage. While suitable sites can be limited because of the need for a receiving body of water adjacent to the field, saturated buffers require very few additional materials and resources; simply a control structure and lateral tile line parallel to the stream.

To learn more about buffer strips or other conservation drainage options, see Additional Resources.

Additional Resources

SDSU Extension, Saturated Buffers video [youtu.be/GzRCi_wWNLM]

Iowa State University, Establishing and Managing Pollinator Habitat on Saturated Riparian Buffers publication [store.extension.iastate.edu/product/15730]

Conservation Drainage Network website [conservationdrainage.net/]

Purdue University, Questions and Answers about Saturated Buffers for the Midwest publication [extension.purdue.edu/extmedia/ABE/ABE-160.pdf]

Acknowledgements

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References

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