Denitrification Within Saturated Riparian Buffers Re-Designed to Remove Nitrate From Artificial Subsurface Drainage.

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Introduction

Riparian buffers are a proven practice for removing NO_3 from both overland flow and shallow groundwater. However, in landscapes with artificial subsurface (tile) drainage, most of the subsurface water flow leaving fields is passed through the buffers in tile drainage pipes leaving little opportunity for interaction with the buffer and limited NO_3 removal. In this study, we investigated the feasibility of re-routing a fraction of field tile drainage as subsurface flow through a riparian buffer for increasing NO_3 removal.

Methods

- Research was conducted on a 48-ha production field in central Iowa (Fig. 1a)
- The field was used to grow corn and soybean in a 2-yr rotation
- Bear Creek, a 3rd order stream ran along the field's northern edge
- Between the stream and field was a 20-m wide riparian buffer established in 1995 consisting of silver maple trees, shrubs, and switchgrass
- A tile outlet draining ~10.1 ha of the field was intercepted as it crossed the buffer and a flow diverting control box installed
- The control box had of 3 chambers separated by two sets of stoplogs (Fig. 1b).
  - Field tile inflow entered the 1st chamber, flowed over the 1st set of stoplogs entered the middle chamber, flowed over the 2nd set of stoplogs then entered the 3rd chamber which was connected to the tile outlet flowing to the stream.
  - The middle chamber of the control box was connected to a 10 cm (4 in) diameter lateral perforated distribution pipe installed perpendicular to the buffer, 75 cm below the surface, and running 335 m along the top of the buffer.
  - By adjusting the height of the stoplogs separating the chambers in the control box, the water level could be raised and water diverted into the distribution pipe from which water then infiltrated into the buffer as shallow groundwater (Fig. 2a)
  - The rate of water flowing out of the 1st and middle chambers was measured every hr by pressure transducers measuring the height of water flowing over V-notch weirs installed on top of each set of stoplogs
  - Flow into the buffer was calculated by the difference between measured inflow and outflow from the control box
- Water that did not infiltrate into the buffer was discharged into Bear Creek.
- 4 well transects of 3 wells each were installed across the width of the buffer and nitrate concentrations in the shallow groundwater below the buffer was monitored every week when the tile was flowing (Fig. 1a)

Results

- Over 2 yr, more than 18,000 m^3 of drainage water was diverted through the buffer (Fig. 2)
- This represented 55% of the total tile flow for those 2 yr
- The watertable in the buffer were raised about 35 cm during diversion
- 228 kg of NO_3 was contained in the water diverted through the buffer
- NO_3 concentrations in the groundwater decreased rapidly through the buffer (Table 1) and were below detection (<0.3 mg L-1) near the stream
- Indicating that all the NO_3 diverted through the buffer was removed by the buffer – most likely by denitrification

Conclusions

Re-directing tile drainage as shallow subsurface flow through a riparian buffer increased the NO_3 removal benefit of the buffer and is a promising management practice to improve surface water quality within tile-drained landscapes.

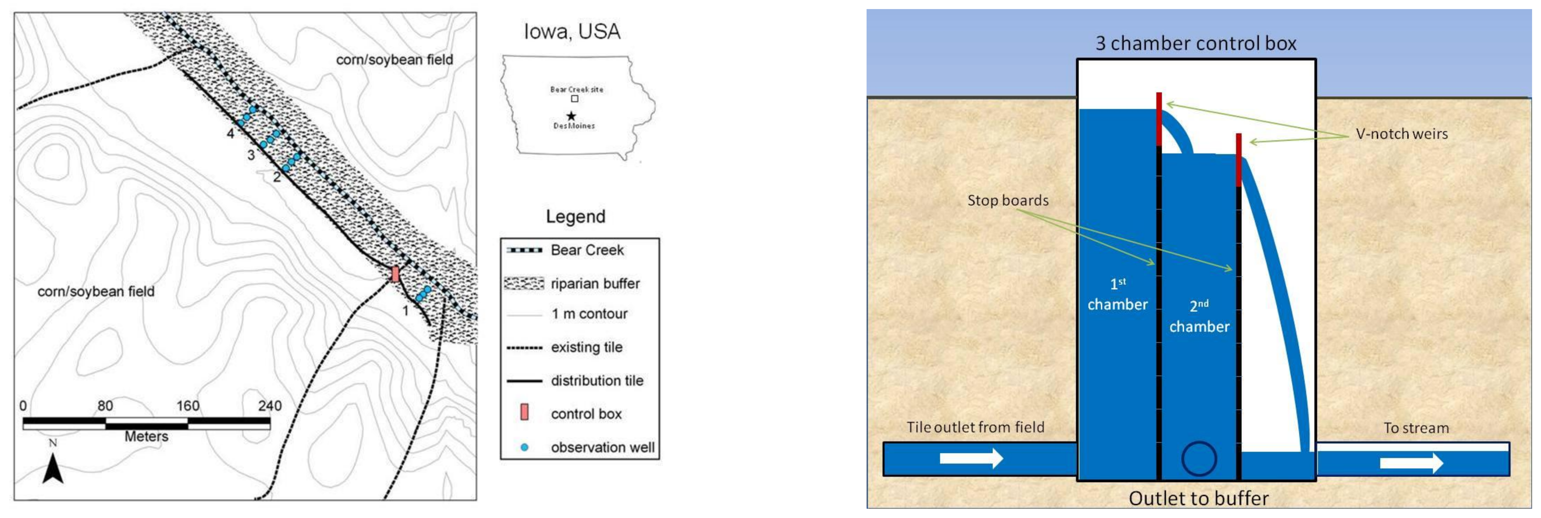

Figure 1. (a) Schematic of the saturated buffer installation at Bear Creek and (b) control box for diverting tile flow.

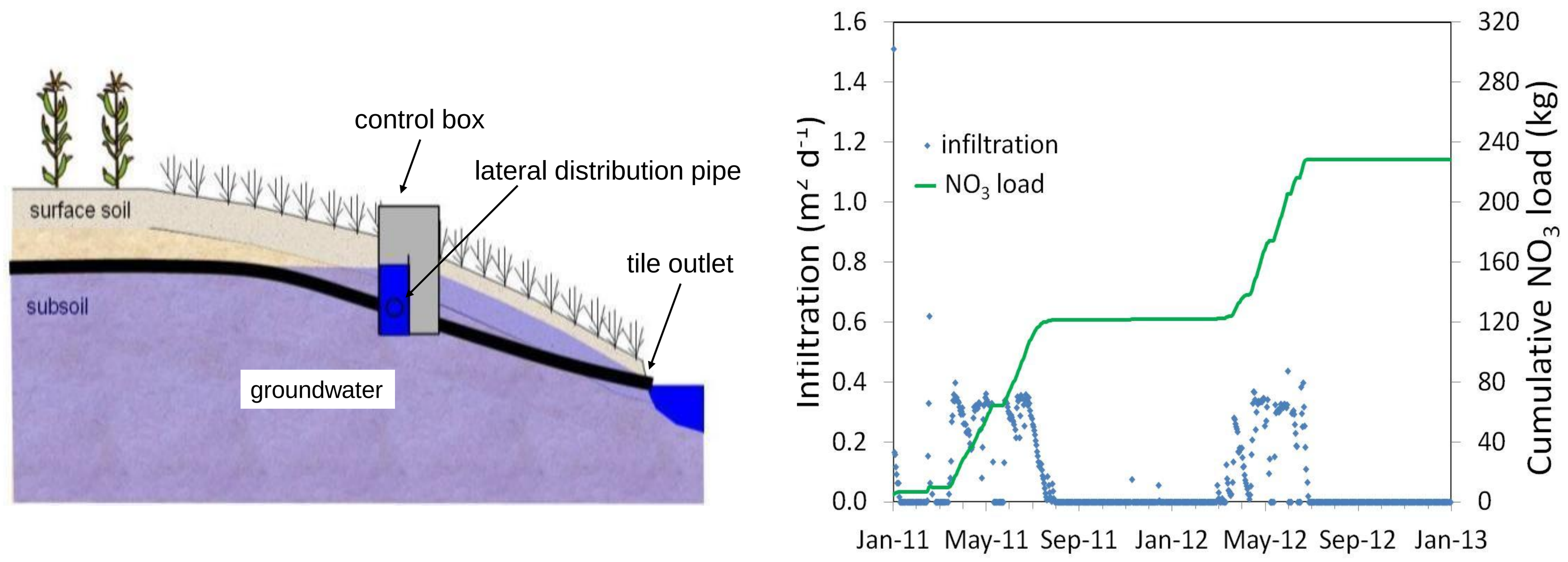

Figure 2. (a) Profile view of groundwater within a riparian buffer raised by diverting tile discharge and (b) Infiltration rate of tile drainage into buffer and cumulative NO_3 mass removed by buffer for 2011 and 2012.

Table 1. Nitrate concentrations of tile water redirected into the buffer and NO_3 concentrations in shallow groundwater along four transects between the field-edge of the buffer and Bear Creek.

Date	Input from field tile	Transect - well number 1-1	1-2	1-3	2-1	2-2	2-3	3-1	3-2	3-3	4-1	4-2	4-3
		distance from distribution pipe (m)											
		5.7	12.7	18.9	5.7	12.9	21.4	6.6	14.1	22.9	6.0	14.1	22.2
	NO_3 concentration (mg N L^{-1})												
2/28/11	9.8	7.9	†		0.8			4.1			1.8	5.1	
3/17/11	9.3	8.9	0.5		0.4			6			1.3		
4/20/11	10.1	8.1						4.8			3.7	0.8	
5/3/11	11	8	1.6					2.5			2.5		
5/19/11	11.6	8.2	1.4					2.3	0.7		1.9		
6/3/11	10.9	7.7	4.8					2.3			2.9		
6/16/11	11.8	13.1	3.6					1.5			4.4		
6/28/11	11.1	7.2	2.4					1.5			3.1		
7/14/11	13	8.2	3.8					3.1			5.1		
7/26/11	11.9	7.7	5.5					4.6			2.5		
3/27/12	14.1	3.8											
4/2/12	13.2	6.9											
4/10/12	13.4	4.6	0.8										
4/16/12	15.1	6.1	0.9										
4/23/12	14.9	8.4	0.5										
4/30/12	13.9	8.6									0.3		
5/7/12	15.9	9.7	0.5								0.6		
5/14/12	14.7	8.4	2.4								0.6		
5/21/12	16.3	9.8	3.1								0.5		
5/29/12	14.6	9.6	3.6					0.6			0.6		
6/4/12	15.8	10.6	4.7					2.7			2.4		
6/11/12	14.3	8.8	6					2.7			3		
6/18/12	16.2	14	5.6					4.7			1.2		
6/25/12	n.s.‡	12.9	7.3					3.8			1		

† missing entries < NO_3 detection limit of 0.03 mg N L^{-1}
‡ no sample