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FEATURE

Looking for agricultural water quality protection practices: Saturated buffers

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Water quality protection practices have become increasingly important as farmers seek to reduce nutrient loss from their fields into receiving streams, lakes, and rivers. These practices are valuable tools for farmers to meet nutrient reduction goals to protect local, regional, and national water resources. In general, farmers have responded well to developing nutrient management programs to use nutrients efficiently and effectively. In-field nutrient management such as 4R nutrient stewardship has helped farmers increase nutrient efficiency on their farms. However, weather and precipitation uncertainty each year make it impossible to perfectly match nutrient management with crop utilization. In addition, the solubility of nitrate-nitrogen (NO_3-N) makes it impossible to control with in-field management practices alone. For these reasons, edge-of-field practices are being developed to intercept NO_3 leaving fields, and saturated buffers are a new and emerging practice to integrate into farm operations to reduce NO_3 loss.

A saturated buffer is a NO_3 reduction, water quality protection practice that intercepts tile drainage before it outlets directly into a stream (or drainage ditch) and diverts a portion of the drainage into a buffer strip that parallels the stream (figure 1). The practice features a control structure or box that directs a portion of the drainage water from the original tile line into a perforated lateral tile that runs parallel to the outlet or receiving stream. The perforated lateral tile releases the diverted water into the soil, where it travels as shallow groundwater through the buffer and into the receiving stream. During the shallow groundwater travel, it is subjected primarily to denitrification processes, but also nutrient uptake by perennial plants in the buffer. In this manner, the saturated buffer practice has the ability to remove a significant portion of the NO_3 from drainage water that would normally pass unimpeded through the buffer in a nonperforated tile and deliver its entire NO_3 load into the receiving stream.

An important function of the control structure is to divert and elevate flow from the tile line into the perforated lateral in a manner that saturates the subsoil of the buffer, brings NO_3-rich water into the biologically active portion of the soil, and creates an optimal condition for denitrification. Stop logs in the control structure divert as much tile drainage into the lateral as possible. However, in times of high runoff, the structure allows excess water to pass over the stop logs and run directly to the receiving stream. This allows the drainage system to function as designed and crop productivity to be maintained. It is important that water quality protection practices achieve their objective without resulting in yield reductions.

PRACTICE PERFORMANCE

USDA Agricultural Research Service researcher Dan Jaynes led a team to measure the effectiveness of saturated buffers in field installations. A collaborative project between USDA, the Agricultural Drainage Management Coalition, and the Agricultural Drainage Management Systems Task Force was funded by a USDA Natural Resources Conservation Service (NRCS) Conservation Innovation Grant to install saturated buffers at 9 locations, and the Farm Service Agency funded installation of the practice at an additional 6 locations (figure 2). The 15 sites, located in Indiana, Illinois, Iowa, and Minnesota, were monitored for NO_3 removal as well as other aspects of practice performance.

The project report data from these 15 sites indicates that there were different levels of success at different saturated buffer sites (Utt et al. 2015). The positive news was that there were a number of high performing sites where virtually all of the NO_3 diverted into the buffers was removed before reaching the stream. This tells us that properly designed and properly installed saturated buffers in appropriate landscape positions with suitable soil properties can result in effective denitrification. Let's look deeper into that statement.

Optimal denitrification occurs in an anaerobic, biologically active soil condition. Thus it is important that the control structure and perforated lateral moves water into the buffer in a manner that raises the shallow water table to an elevation that brings it into contact with biologically active soil. Soil carbon (C) is the fuel for soil biologic activity. The researchers suggest that 2% organic C at 0.8 m (2.5 ft) will easily support denitrification, and that 1% is a minimum. Well-established streamside buffers with deep-rooted perennials

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Figure 1

Aerial view of a saturated buffer. Image courtesy of Agri Drain Corporation.

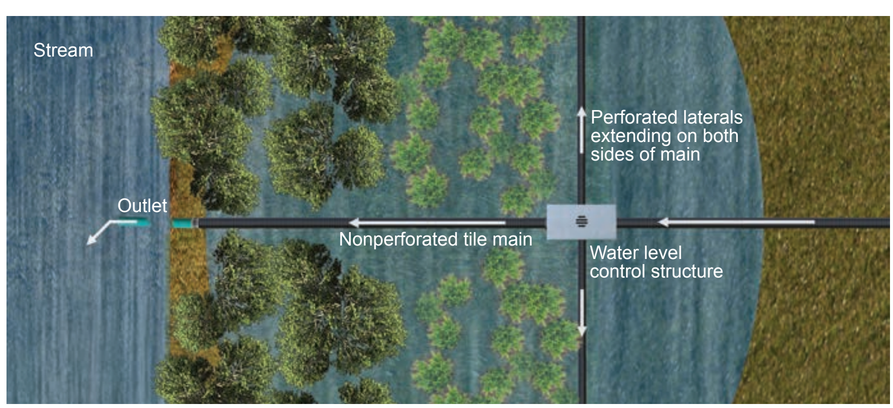

Figure 2

A saturated buffer site (a) during lateral tile installation, (b) during buffer seeding, and (c) after buffer vegetation and crop growth. Photos by Lynn Betts.

should have little difficulty meeting the soil C requirement.

In a number of the established sites, NO_3 reduction performance was significantly less effective. However, these sites provided equally valuable information as they identified conditions to be avoided in siting and installing saturated buffers. Sand or gravel layers from historic channels and abandoned tile can short circuit the buffer and move water directly from the perforated tile to the receiving stream. They may also make it difficult to raise the shallow water table to an effective level for denitrification to occur. Site investigations prior to practice installation are important as they provide the best opportunity to identify these conditions and allow a determination regarding the suitability of the site.

IMPLEMENTATION CONSIDERATIONS AND POTENTIAL FOR APPLICATION

Water quality protection is an ongoing challenge for farmers and the agriculture industry. To meet nutrient reduction objectives necessary to protect the nation's water resources, farmers are going to have to employ conservation systems specifically designed to reduce nutrient loss from their farms. In each case, it starts with nutrient management strategies that effectively utilize nutrients and minimize nutrient loss to the environment. However, in many cases additional edge-of-field or downstream practices may be necessary to achieve appropriate nutrient reduction levels.

Saturated buffers are an edge-of-field practice that intercepts tile discharge into streams, redirects a portion of the discharge into shallow groundwater flow through vegetated buffers, and effectively removes NO_3 as the shallow groundwater moves to the receiving stream. While proper site selection is important to their success, there are thousands of kilometers of streamside buffers in which the practice can be effectively established.

The Jaynes et al. results show that design and installation have a large impact on saturated buffer performance. USDA NRCS Conservation Practice 604 describes site investigation and construction criteria necessary to result in an effectively functioning saturated buffer system (USDA NRCS 2016).

Conservation professionals need to be trained regarding the role of the practice in meeting water quality protection objectives and become comfortable communicating the function and value of saturated buffers to farmers and agribusiness. It is important to begin a public information program to make farmers aware of saturated buffers as a conservation practice that can help them achieve their conservation and stewardship goals for water quality protection.

However, financial incentives for installing the practice are also an important consideration for the farmer. While a saturated buffer may be a very effective water quality protection practice, its installation does not result in a direct economic or on-farm resource protection benefit for the farmer. The benefit of the practice is to the environment and all of us who benefit from improved water quality.

Finally, research and the monitoring of installed saturated buffer systems needs to continue to better understand the denitrification that occurs in the buffer and conditions that can improve the process. Agribusiness has produced the control structures and equipment to install and operate the system. We need to continue to learn how to improve the practice until it becomes a well understood and effective tool for water quality protection.

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