TILE DRAINAGE SELF-ASSESSMENT: WHAT CAN I EVALUATE? [1/]

Eric Cooley[2/], Tim Radatz[3/] and Aaron Wunderlin[4/]

Background

Many farmers in the Upper Midwest use agricultural tile drainage to produce crops. Farmers in Wisconsin and Minnesota have been using agricultural tile drainage for decades. Tile drainage is used to achieve moisture conditions that improve field access, promote crop growth and yield, and decrease surface runoff. Tile drainage can also serve as a conduit for sediment and nutrient transport to surface waters and more information and education is needed to reduce this potential pathway for transport.

Most of the farmland that contains tile drainage in Wisconsin is in the Lake Michigan Basin, and in Minnesota, most is in the Mississippi River Basin. Delivery of nutrients to the Gulf of Mexico through the Mississippi River results in a hypoxic zone that affects aquatic life and the industries that depend on it. Delivery of nutrients to the Great Lakes or other freshwater sources in Wisconsin and Minnesota results in algal blooms and eutrophic conditions that are harmful to aquatic life and interfere with intended uses. Water quality impairment in both states is largely attributed to intensive agricultural land use.

Discovery Farms is an edge-of-field water quality research and outreach program focusing on farmer leadership, credible research design and implementation, and effective communication of results. The Discovery Farms programs in Wisconsin and Minnesota have been collecting edge-of-field surface runoff and tile flow data for 15 to 20 years. Many relationships between farming practices, sediment, and nutrients of surface runoff and tile flow have been quantified through the program's extensive monitoring network. However, this type of intensive edge-of-field water quality monitoring is expensive to operate and difficult to site, which limits the number of farmers able to participate.

This project significantly added to the existing tile water quality monitoring efforts and knowledge, specifically:

- Demonstrated the potential add-on or alternative to current edge-of-field NRCS practice standards making edge-of-field monitoring a more accessible diagnostic for farmers and farm advisors.
- Identified agricultural practices and field conditions where the potential for loss from tile drainage is high and assessed available practices to reduce losses.
- Provided multiple approaches to information transfer, allowing information from the project to reach many farmers and stakeholders.

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[2/] Director, UW Discovery Farms, 2019 Technology Way, Rm 127, Green Bay, WI 54311.
[3/] Discovery Farms Coordinator, Discovery Farms Minnesota, 3080 Eagandale Place, Eagan, MN 55121.
[4/] Research Coordinator, UW Discovery Farms, 2019 Technology Way, Rm 126, Green Bay, WI 54311.

Methods

Three tiers of water quality monitoring were assessed: intensive, intermediate, and basic. Intensive tile flow and water quality data was collected from 8 locations, one in each specified county area (Fig. 1). Intensive sites utilized automated sampling equipment and a flow based sampling approach, including dataloggers, ISCO water samplers, and remote communications. Water samples from intensive sites were analyzed for suspended sediment, total Kjeldahl nitrogen, ammonium, nitrate, total phosphorus, dissolved phosphorus, chloride, total organic carbon, and dissolved organic carbon. Bi-weekly grab samples were also taken at these sites to assess the lower cost monitoring approach.

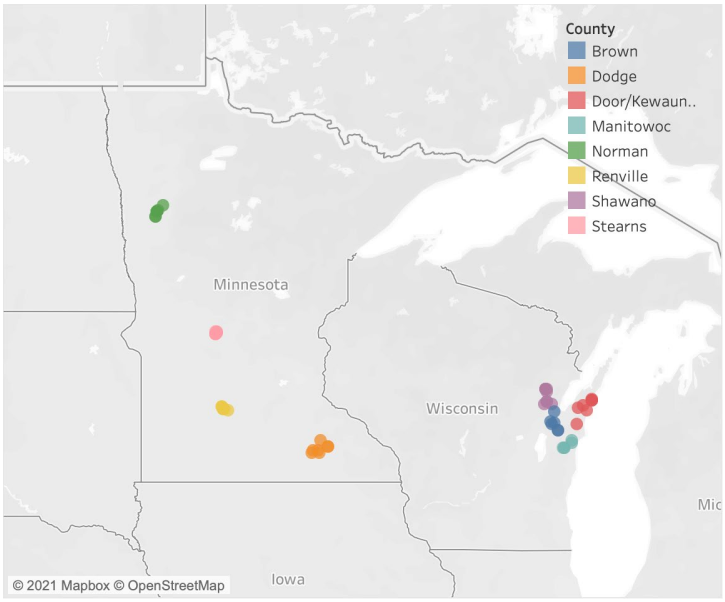

Figure 1. Tile drainage monitoring locations in Minnesota and Wisconsin.

There were 20 intermediate sites and 20 basic sites in the project. Intermediate sites included continuous flow monitoring and bi-weekly water sampling. Basic sites included bi-weekly flow monitoring and water sampling. Water samples from the intermediate and basic sites were analyzed for suspended sediment, dissolved phosphorus, total phosphorus, and nitrate. Agronomic information was collected for each location to correlate cropping and field management practices to water quality results.

Results

If measuring flow is a necessity, the intensive and intermediate approaches in this project would produce reliable results. Flow measurement of the intensive approach was reliable under all conditions. The only flow measurement limitation of the intermediate approach is during pressurized flow conditions where water levels don't necessarily correspond to flow rates. This happened at different sites throughout the project, although these pressurized flow periods had limited impact on annual runoff totals. The basic approach is insufficient for annual flow measurements as there is too much variability to only measure once every 2 weeks.

Bi-weekly samples were taken at intensive sites along with the flow based automated sampling to compare results of these two methods. Flow weighted mean concentrations (total weight lost per year divided by the total volume of tile flow) of the flow based automated sampling were compared with annual averages of the bi-weekly grab samples at all intensive sites. The bi-weekly sampling approach underestimated sediment, total phosphorus, and dissolved phosphorus concentrations (Fig. 2). This is likely because bi-weekly sampling events missed most of the high flow periods where sediment and phosphorus concentrations are typically higher. The bi-weekly sampling approach produced excellent results for nitrate concentrations, average bi-weekly concentrations were consistent with flow weighted mean concentrations. The intermediate and basic sampling approach produced reliable nitrate concentration values, but underestimated sediment and phosphorus. If reliable sediment and phosphorus concentrations are needed, an automated flow-based approach is essential.

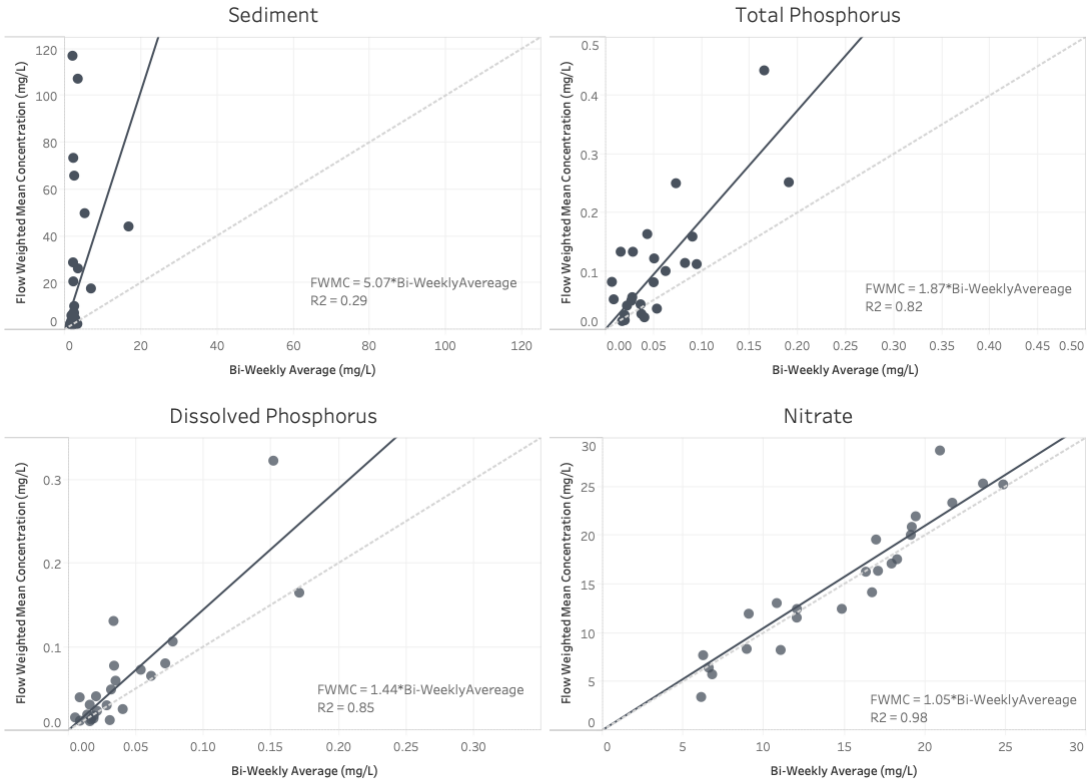

Figure 2. Comparison of continuous flow weighted mean concentration to biweekly concentration for sediment, total phosphorus, dissolved phosphorus, and nitrate in tile drainage water.

Discussion

The bi-weekly sampling approach for nitrate concentration produced results that representative for continuous flow monitoring. Therefore, grab sampling for nitrate may provide a good self-assessment tool for nitrogen management in tile drained cropland. Seasonal nitrate concentration values can aid in the assessment of nitrogen products, rates, timings, and methods of nitrogen management programs to gain knowledge of nitrogen use efficiency and decrease nitrogen losses to tile water (Table 1).

Table 1. General guidelines for interpreting NO_3-N concentrations in tile drainage water. The interpretation is derived from numerous studies conducted throughout the cornbelt and highlights land management strategies commonly found in association with a concentration measured in tile as the tile leaves the edge of the field. (Brouder et al., 2005)

NO_3-N concentration (ppm)	Interpretation
≤ 5	Native grassland, CRP land, alfalfa, managed pastures
5 – 10	Row crop production on a mineral soil without N fertilizer Row crop production with N applied at 45 lbs/acre below the economically optimum N rate† Row crop production with successful winter crop to "trap" N
10 - 20 Row crop	Row crop production with N applied at optimum N rate Soybeans
≥ 20	Row crop production where: • N applied exceeds crop need • N applied not synchronized with crop need • Environmental conditions limit crop production and N fertilizer use efficiency • Environmental conditions favor greater than normal mineralization of soil organic matter
† Economically optimum N rate is the rate that maximizes the return on investment in N fertilizer and therefore may be slightly lower than the N rate that maximizes crop yield.	

It should be noted that some monitored tile systems, specifically in Wisconsin, flowed continuously. A few of these tile systems with continuous flow produced more flow volume than total precipitation, therefore indicating interception of groundwater or perched water tables. Concentrations of all monitored analytes were comparatively low in these tile systems as compared to those that flowed less continuously. Knowing tile flow trends is important for proper assessment of nitrate concentrations in tile.

Reference

Brouder, S., B. Hofmann, E. Kladivko, R. Turco, A. Bongen, and J. Frankenberger. 2005. Interpreting nitrate concentration in tile drainage water. Agronomy Guide. Purdue Extension AY-318(W). West Lafayette, Indiana.