The influence of the two-stage ditch on water quality in an agricultural landscape

Workshop on Nutrient Management Challenges & Solutions
Streams draining row crop agriculture export excess nutrients and sediments

- In Indiana, >90% of the over 50,000 km of stream/ditches are located within 500 m of a row-crop field.
- Fertilizer addition, channelization, and tile drainage improve crop yields, but these practices also reduce nutrient retention and channel stability.

**Net Result:** drainage modification results in increased export of excess nutrients and sediments to downstream water bodies.
Agricultural land use in Midwest contributes to Gulf of Mexico and Great Lakes hypoxia

- Runoff of excess nutrients to adjacent streams/ditches, and export to downstream ecosystems can cause nuisance algal blooms in aquatic ecosystems.

- The Gulf of Mexico and Lake Erie undergo annual periods of hypoxia (i.e., “dead zones”) as a result of excess fertilizer runoff.

- Peak run-off occurs during spring snowmelt and rain events.

Alexander et al. 2000
New in-stream management tool: two-stage ditch

- Increase channel stability
- (predict) increased sedimentation $\rightarrow$ particles settle out on floodplains
- (predict) increased nutrient retention $\rightarrow$ more time/space for removal
Two-Stage Ditch Monitoring

1. Can we reduce sediment and phosphorus export?
2. Can we increase nitrate-N removal?
Two-stage floodplains slow water velocities during storms

- Agricultural streams have flashy discharge, especially during winter/spring.
- Storm flows inundate two-stage floodplains, but duration varies in wet and dry years.
- Net effect: decrease in water velocities, and increased sedimentation.

Tank et al. unpublished, manuscript in prep.
Does the two stage influence sediment export?

- Two-stage reduced water column turbidity at all sites, no matter when it was constructed.
- Turbidity correlates with total phosphorus (TP).
- Reducing sediment load may reduce particle-associated P export.

Take home: With no additional maintenance, the two-stage ditch appears to slow water velocity during storms, allowing sediments to deposit onto benches, with possible TP benefits.

Tank et al. unpublished, manuscript in prep.
Does the two stage influence sediment nitrogen removal?

- During flooding, the two-stage significantly increased reach-scale N-removal; rates are 2-14x higher than channelized reach.

- Reach scale N removal increases as the two-stage ages.

- Mechanism: older floodplains have richer soils, supporting higher denitrification rates.

Take home: Two-stage floodplains “mature” through time, and denitrification N removal improves without additional stream management.

Tank et al. unpublished, manuscript in prep.
Does the two stage influence water chemistry?

- We monitored water chemistry using paired sampling (difference in two-stage vs. upstream channelized reach).
- Two-stage reduced dissolved P concentrations (as SRP), but reduction was site dependent.
- In contrast, no decrease in NO$_3^-$, concentrations high.
- Potential to reduce SRP export, but NO$_3^-$ currently too high to be reduced by short segment of two-stage (~600m).

**Take-home:** Efficacy could be improved if length extended or practice combined with other land management practices to reduce nutrient inputs.

Tank et al. unpublished, manuscript in prep.
Can two-stage floodplains reduce nitrate during baseflow?

- Tile drains carry high NO$_3^-$ drainage to streams.
- During base-flow, the two-stage reduced NO$_3^-$ nitrate from tiles by 6-20% depending upon length of flow path.

Take-home: Retention of tile drain flow on benches during base flow may improve N removal efficacy; further trials planned.
Summary: effects of two-stage ditch on water quality

- During storms, the two-stage can reduce sediments and increase nutrient removal via floodplain inundation, which can be extensive depending on water year and height of floodplain construction.
- During baseflow, two-stage floodplains can also reduce NO$_3^−$ in tile water as flowpath moves across vegetated floodplains.
- With no additional maintenance, the two-stage practice “ages” well over time and function improves, making it a self-sustaining practice.

Take-home: The two-stage is a potential tool in the nutrient management toolbox that can be implemented to improve water quality while coexisting with productive agriculture.
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