Phosphorus Retention in Restored Agricultural Floodplains

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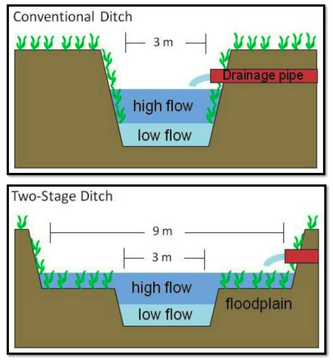
Research Problem

- The two-stage channel design has been proposed as a strategy to decrease nutrient loads from agricultural watersheds.
- Inset floodplains increase nitrogen removal by denitrification and biological uptake (Roley et al. 2012).
- Previous work has demonstrated that there is a potential for P removal (Davis et al. 2015), but the controlling factors are not well understood.



Two-stage channel design. *Roley et al. 2014*

Hypotheses and Approach

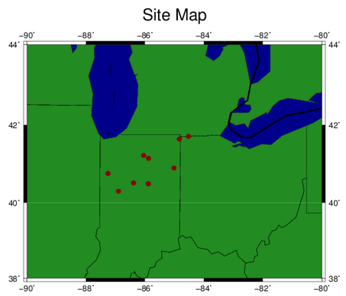
1. Does two-stage implementation enhance P retention capacity on the created inset floodplains?

Hypothesis: The two-stage channel will have a higher P retention capacity and be a stronger sink for P than its unmodified counterpart. This will be driven primarily by organic matter build-up on the floodplain benches, and will be more pronounced in older systems.

2. Does two-stage implementation change the P properties of streambed sediments?

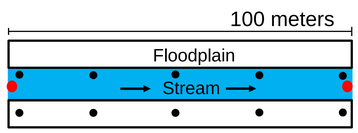
Hypothesis: Coarsening of streambed sediments will lead to a lower P retention in two-stage compared to conventional channels. Low surface area will leave few sorption sites and less space for biofilm growth.

Field Work: Sampling blitz at ten two-stage sites around Indiana



Two-stage channel in northern Indiana

- Two 100 meter reaches at each site – one with an inset floodplain, one conventional channel
- Sampling during baseflow
- Collected soil samples from 5 transects along each reach from the streambed and banks
- Soils were homogenized by location before lab analyses

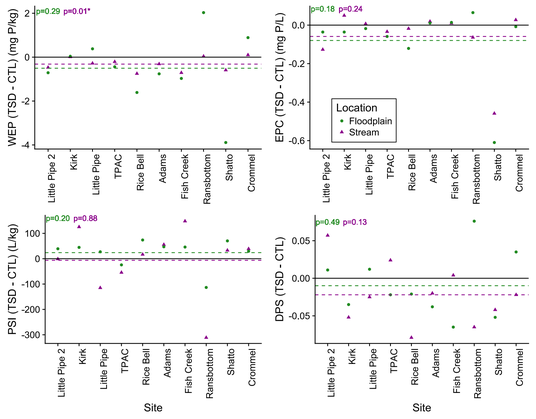


Laboratory Analyses
- ❖ Water-extractable P
- ❖ Equilibrium P Concentration (EPC_0)
- ❖ Organic matter
- ❖ Particle size analysis
- ❖ Phosphorus Sorption Index (PSI)
- ❖ Chlorophyll a
- ❖ Oxalate-extractable Fe, Al, P

Results

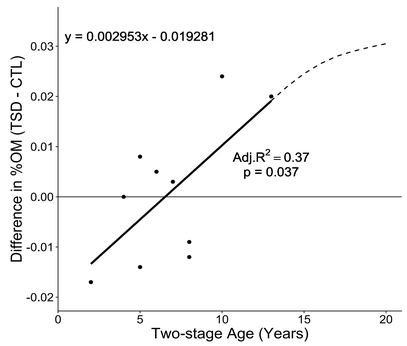
				Particle Size Analysis			
	Location	Moisture Content (%)	Organic Matter (%)	Sand (%)	Silt (%)	Clay (%)	Chla (mg/L)
Stream	**Two-stage**	28 ± 5	3.9 ± 1.0	40 ± 10	50 ± 7	10 ± 3	0.9 ± 0.3
	Conventional	28 ± 6	4.5 ± 1.6	40 ± 10	50 ± 8	10 ± 4	1.4 ± 0.7
Floodplain	**Two-stage**	31 ± 4	6.5 ± 0.9	34 ± 11	56 ± 8	10 ± 4	1.1 ± 0.7
	Conventional	28 ± 3	6.5 ± 0.9	34 ± 11	56 ± 8	9 ± 4	0.9 ± 0.5

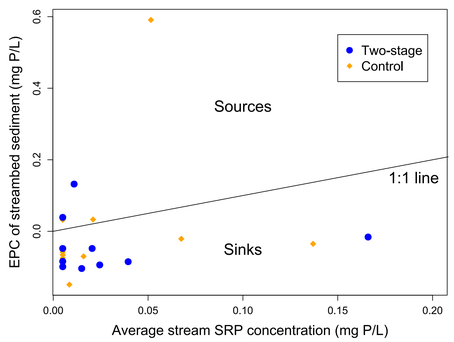
- **Soil properties of inset floodplains were similar to stream banks in conventional channel**
- Organic matter was higher on the floodplain soils than the stream sediments
- Floodplain generally had more silt and less sand than streambed sediments



- **Water-extractable P (WEP) was the only statistically different soil P property between the two-stage and conventional channels**
- High among site variability; stream & floodplain values tracked each other suggesting watershed scale drivers
- Plotted points are the difference between two-stage and control values at each site
- Dashed line is mean soil P property; p value from paired t-test

- **Organic matter builds up over time on floodplain benches**
- There is ~2% drop in organic matter after two-stage channel installation and regains ~0.3% organic matter more than the control reach each year
- The two-stage "catches up" 7 years after implementation and continues to increase over time
- Organic matter was driver of PSI
- Does this reach a threshold/maximum?

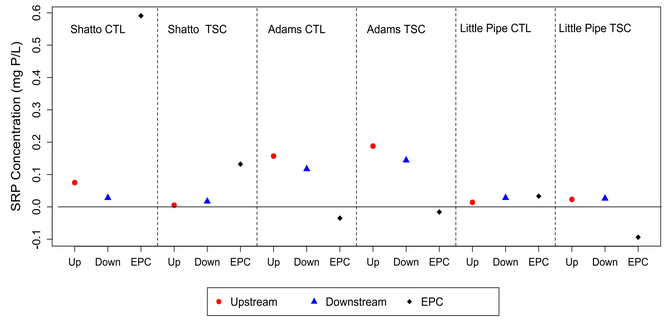




- **Most reaches were sinks for phosphorus**
- Points below the 1:1 line have SRP>EPC_0, indicating that soils should function as a sink of P
- The variability between sites was much greater than the variability between two-stage and conventional channels

Results (Continued)

How good is EPC_0?



- **Of 20 reaches, 8 had significant SRP concentration changes**
- **EPC_0 was predictive of P concentration change at 5 of those 8 reaches**
- If EPC_0 is a good predictor, we would expect SRP concentrations to get closer to the EPC_0 as water moved from upstream to downstream
- Hypothesize that discrepancy is likely caused by biological uptake and groundwater inputs

Conclusions and Future Work

- There were little differences in soil properties between the two-stage and control channels for these ten sites sampled at baseflow conditions
- However, a larger wetted area could lead to higher overall nutrient retention during storm events
- Organic matter was a key driver of soil P properties
- We may need to evaluate the success of floodplain restoration projects over longer timescales (10+ years)
- This study was conducted at baseflow conditions. How do these P properties change seasonally, and during storm events?

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