Temporal Variability in Water and Nutrient Movement Through Vertisols into Agricultural Tile Drains in the Northern Great Plains

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Introduction

- The expansion of agricultural tile drainage in the Northern Great Plains of North America is occurring, yet is controversial due to persistent water quality problems such as eutrophication.
- Vertical preferential flow in clay-rich soils has been found to contribute to water and nutrient loss in some tiled landscapes.
- Runoff-generating mechanisms in artificially drained landscapes in North American vertisolic soils have not been investigated.

Objective

To characterize seasonal patterns in tile flow and chemistry under variable hydroclimatic conditions and relate this variability to soil hydraulic properties.

Study Site & Methods

- Study site was a 25-ha farm in Elm Creek, Southern Manitoba, Canada (~70 km from the city of Winnipeg, Canada)
- 10" lateral tiles at 40 ft intervals at ~1 m depth
- Tile flow and chemistry monitored from 2015 to 2017.

Figure 1. Layout of the study field. Black lines represent the lateral tiles.

- In 2017, a series of surface infiltration and slug tests were conducted to assess the surface and subsurface hydraulic conductivities under a range of antecedent conditions (April: frozen, wet; June: Thawed, wet; July & October: Thawed, dry)

Results and Discussion

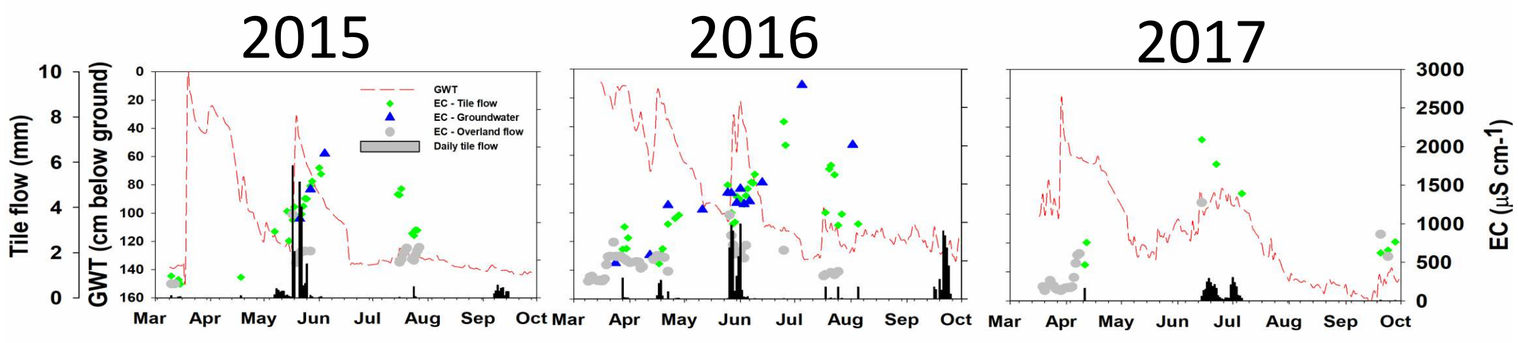

Figure 2. Daily tile flow, groundwater table position and the electrical conductivities of the tile water, groundwater and overland during the study period.

- Tiles barely flowed during early spring snowmelt and summer.
- Substantial tile flow associated with shallow GWT late spring (May-June).

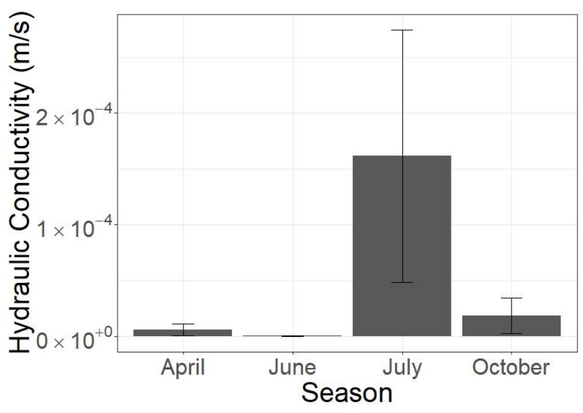

Figure 3. Surface hydraulic conductivities determined experimentally in 2017 under variable antecedent moisture and temperature conditions.

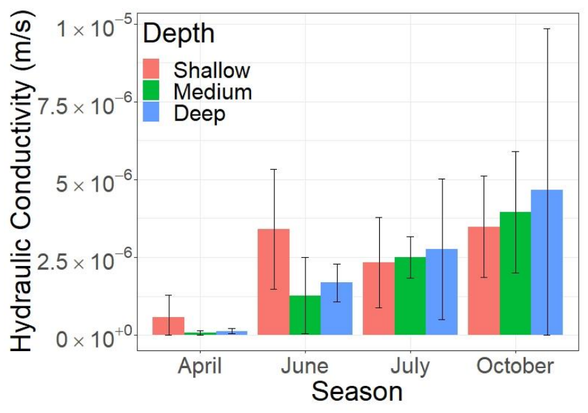

Figure 4. Subsurface hydraulic conductivities observed from slug tests during periods of 2017 with different antecedent moisture conditions.

- Retardation of surface (Fig. 3) and subsurface (Fig. 4) vertical water movement due to a thick frozen soil-ice layer responsible for poor tile performance during early-spring snowmelt in this region
- Surface infiltration minimal during wetter conditions (June) and greater during drier conditions (July) due to swelling and shrinking of cracks
- These dynamic conditions (crack activity) affected tile flow chemistry

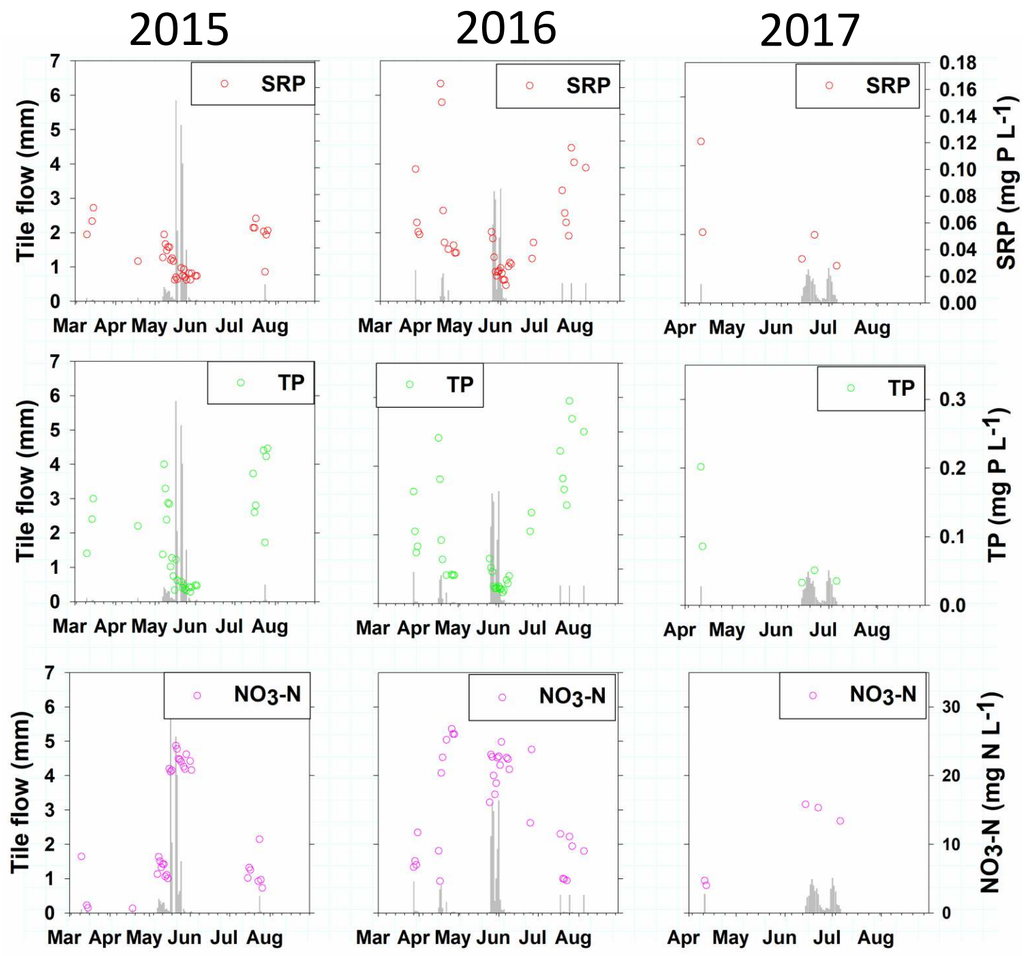

Figure 5. Daily flow-weighted soluble reactive phosphorus (SRP), total phosphorus (TP) and nitrate concentrations during the study period. Tile flow is shown with grey bars.

- Greater SRP and TP concentrations and lower nitrate and EC concentrations during early spring and summer imply that tile flow was mainly driven by the preferential flow through frozen and dry desiccation cracks. However, nutrient loads small due to small flow volumes.
- Smaller SRP and TP concentrations and greater nitrate and EC concentrations during late spring suggest that tile flow was dominated by matrix flow.

Implications

- Smaller P concentrations during major tile flows indicate that tiles may not exacerbate P runoff losses in the region.
- However, increased nitrate concentrations during major tile flowing periods (i.e. late spring) are a concern.

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