Insights from intensive water quality sampling in a drained agricultural field

Wenlong Liu (wliu14@ncsu.edu)*, Bryan Maxwell, François Birgand, Mohamed Youssef, George Chescheir

Introduction

- Excessive nitrate export from agricultural activities has been recognized as non-point sources of contaminations to receiving water bodies.
- Researchers have made considerable efforts to quantify the fate and transport of nitrate export from agricultural fields, including field investigation, numerical modeling and data mining in large datasets, etc.
- Limited application of high frequency sampling has been conducted in field-scale tile drainage systems and shallow groundwater.
- We hypothesize that high resolution concentration data *in time and in space*, will provide the info necessary to describe and predict the movement and fate of nitrate in and from agricultural fields

Site description

- Research site:
  - ❖ Tidewater research station in Plymouth, NC;
  - ❖ Poorly drained soil with animal waste application from hog farms;
  - ❖ Tile drainage installed;
  - ❖ Depth = 1.0 m, spacing = 12.5 m.
- Drainage flow:
  - ❖ V-notch weir + pressure transducers;
  - ❖ 15 minutes interval.

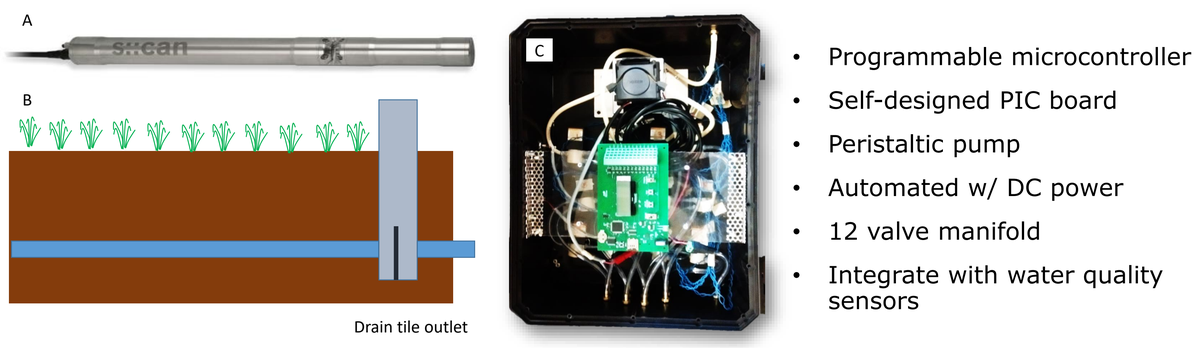
Fig. 1 Location of research site

Fig. 2 Animal waste application

Fig. 3 Flow and water quality measurement equipment

High frequency water monitoring in tile drainage

- Method:
  - ❖ Multi-point sampler (MPS) coupled to field spectrophotometer.
  - ❖ Measuring nitrate (NO_3) and dissolved organic carbon (DOC).
  - ❖ 45 min. sampling interval at drainage tile outlet.
  - ❖ Cuvettes and acid rising every cycle for quality control.



- Programmable microcontroller
- Self-designed PIC board
- Peristaltic pump
- Automated w/ DC power
- 12 valve manifold
- Integrate with water quality sensors

Fig. 4 High frequency measurement equipment in the tile outlet. (A) spectrophotometer, (B) Layout of the measurement equipment, (C) Multi-Point Sampler (MPS) and brief description

- Preliminary results:
  - ❖ Able to capture the detailed hydrograph and chemograph using high frequency sampling approaches.
  - ❖ Peak of chemograph appeared less than 10 hours after the event started.
  - ❖ Illustration of non-linear relationship of nitrate concentration and drainage flow (C-Q relationship).

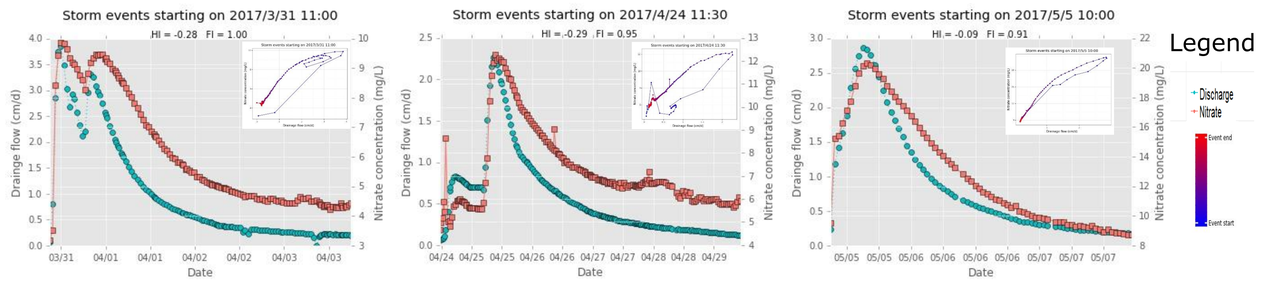


Fig. 5 Hydrograph and nitrate chemograph using intensive in-situ water quality sampling. Small plots indicate the C-Q relationship changing along with time.

Tracking nitrate spatio-temporal dynamics in shallow groundwater

- Experimental design
  - ❖ Sampling wells with concentrated collecting area and air vents (Fig. 6).
  - ❖ In-situ continuous water quality probe.
  - ❖ Self-designed multi-point sampler.
  - ❖ Solar power for remote areas.
  - ❖ Running interval: 6 minutes.
  - ❖ Sampling interval:1 hour for each well

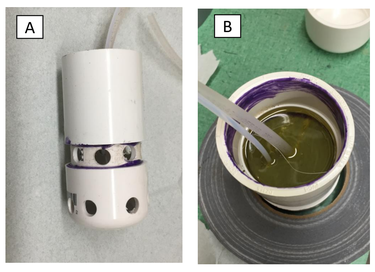


Fig. 6 Modified water quality wells A. Holes to reduce resistance to water flow; B. Sealed by epoxy resin.

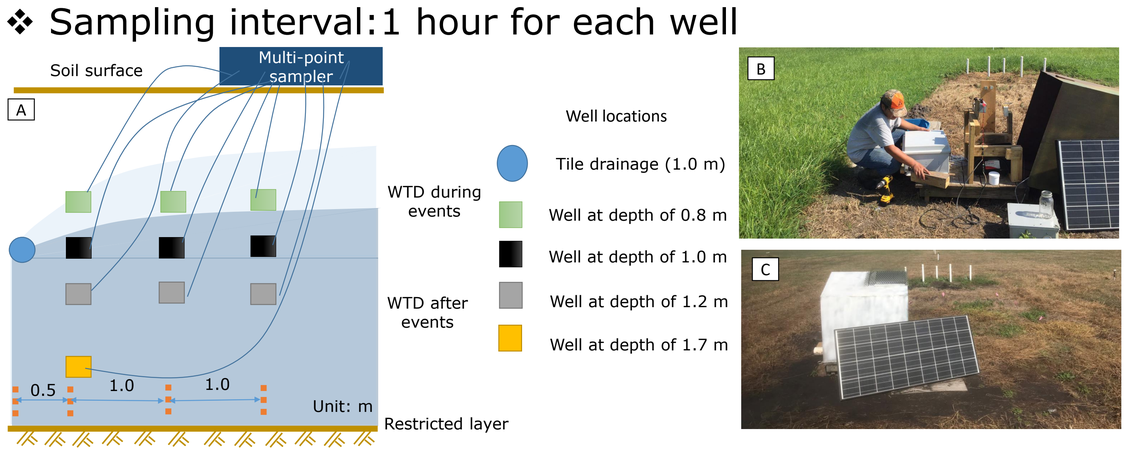
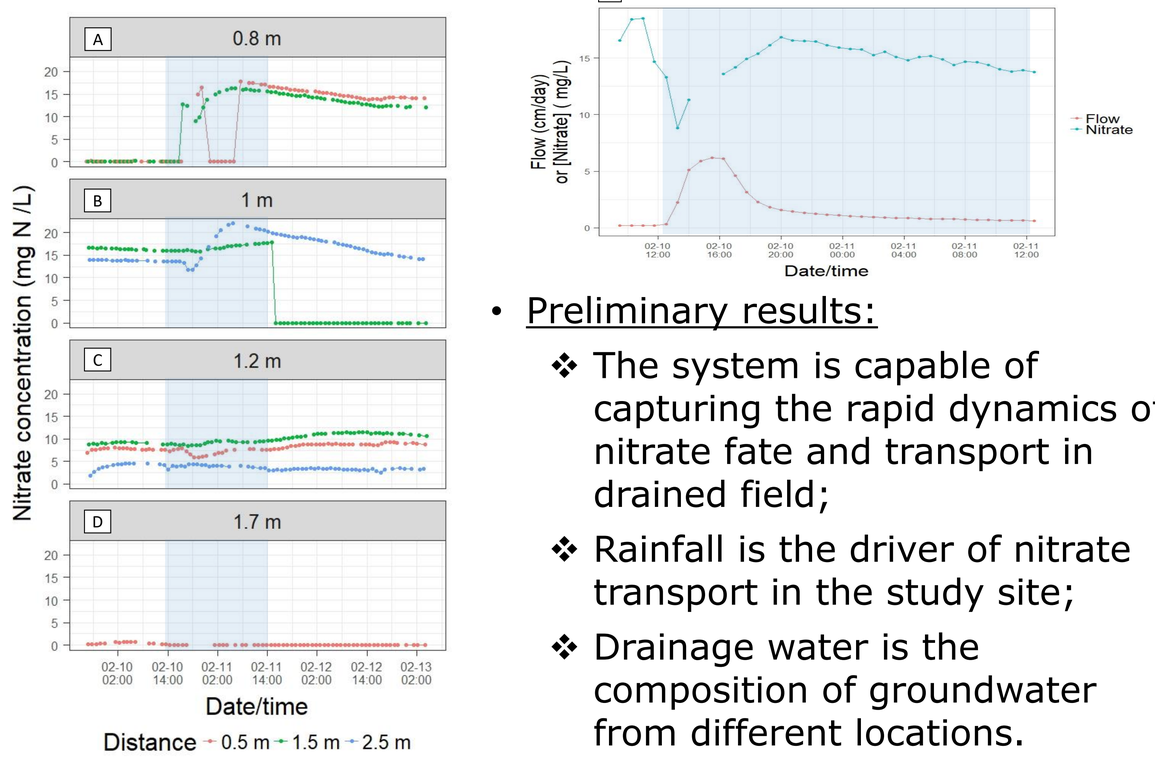


Fig. 7 Conceptual layout of field wells and multi-point sampler (A) and field photos of the shallow groundwater sampling (B and C). Note: the location is not fully scaled.



- Preliminary results:
  - ❖ The system is capable of capturing the rapid dynamics of nitrate fate and transport in drained field;
  - ❖ Rainfall is the driver of nitrate transport in the study site;
  - ❖ Drainage water is the composition of groundwater from different locations.

Fig. 8 Measurements of drainage discharge and nitrate concentration at shallow groundwater (A~D) and drain outlets (E) during one event in Feb 2018. Blue shades represents the period from 2/10/2018 13:00 to 2/11/2018 12:00. Rainfall happened in Feb. 10, 2017.

Conclusions and implications

- Preliminary results indicated that there existed complicated relationships between nitrate dynamics in shallow groundwater and nitrate export in drain tile outlets.
- We need to work on the connection of transport and fate of nutrients in shallow groundwater to drainage outlets.
- Next generation numerical models require high frequency water quality data to calibrate and validate model parameters.

Acknowledgement

This work is supported by the Agriculture and Food Research Initiative [grant no. 2016-67019-25279] from the USDA National Institute of Food and Agriculture. The authors also acknowledge Terry Armstrong from Tidewater Research Station for the assistance of field operations and animal waste application.

Authors

* North Carolina State University, Biological and Agricultural Engineering, Raleigh, North Carolina, United States.

@tianya0423 @birgandwaterlab