Measuring and Monitoring Nitrogen and Phosphorus in Agricultural Drainage Ditches in the Chesapeake Bay

Nutrient Issue

Background: Maryland's Eastern Shore is an important landscape for agriculture in the Mid-Atlantic region, specifically for grain and poultry production. Due to the low-lying and sandy nature of the soils in this area, hydrologic modifications were necessary to make farming possible. Hundreds of years ago, Maryland's Eastern Shore was a marshy, low-lying peninsula with limited acres for farming. Ditching the soils in the 1700s created dependable, dry farmland. These ditches have protected the land from floods and lowered the water table, making production agriculture possible in the region. But research has shown that agricultural drainage, especially subsurface drainage, can have a significant impact on nutrient contribution to downstream surface waters. Nitrogen (N), phosphorus (P), and sediment are transported from the farms fields as runoff that then enters the ditches and carries. These pollutants have the potential to reach local tributaries and eventually the Chesapeake Bay.

According to the Chesapeake Bay Model, the Delmarva Peninsula (comprising of parts of Delaware, Maryland, and Virginia) contributes disproportionate amounts of N and P to the Chesapeake Bay. The Delmarva Peninsula is also home to a high density poultry production, where ~575 million broilers are raised each year. The litter from poultry operations has historically been land applied to farmland in the form of organic fertilizers, usually at N application rates as it was previously thought that the P strongly binds to the soil and not lost to water bodies. This conventional thinking led to an over-application of P, because of poultry litter's N/P ratio, and therefore, has elevated P concentrations in many soils in Delmarva Peninsula. Some soils in Maryland now have high values of soil P and nutrient management regulations in the state restrict applications of P in these soils. Several recent studies have shown that in these artificially drained, coarse textured soils with legacy P inputs, large amounts of P can be lost through subsurface pathways. In addition to P, a plethora of studies have shown that Chesapeake Bay also shows periodic N limitation, suggesting that we need better understanding of how N and P are transported from agricultural land to connected waters (ditches, streams).

Need for Continuous Data: As agricultural ditches and drainage structures are essential to sustainable farming on Maryland's Eastern Shore, researchers and conservation professionals have begun to seek solutions to address the issues of nutrient and sediment pollution from ditches. Some practices such as denitrifying bioreactors, water control structures, ditch filters and P-sorbing materials have the potential to reduce N, P, and sediment losses from agricultural land. In order to understand the effectiveness of these practices, the University of Maryland invested in a network of field instruments infrastructure on the Delamarva Pennisula. Preliminary data was collected but there is still much more work that needs to be done to understand how nutrients are transported from land to water. This infrastructure has not been used for the last few years.

In this proposal, we seek to use the existing sampling infrastructure in conjunction with low cost nutrient sensors to understand the mechanisms and processes driving N and P losses, how agricultural conservation practices can be refined to remove N and P from water passing through agricultural ditches, and how we can fine-tune best management practices to minimize N and P losses from agricultural land to the Chesapeake Bay.

Improved Decision Making: The generation of high-frequency water quality data on nitrate-nitrogen and orthophosphate-phosphorus with low cost nutrient sensors in our monitoring sites will allow us to understand how, when, and why nutrients are transported from land to water. This knowledge will be critical in developing and fine-tuning management practices that reduce N and P losses. This information will be shared through cooperative Extension channels to encourage voluntary adoption of practices by farmers that will reduce nutrient losses. There is also an ongoing effort to create efficiencies for these practices in the Chesapeake Bay Model that this project would help to inform. Building on the previously collected data, we hope to not only inform decisions about the installation of these practices but also help to improve the practices themselves to work better in the Delmarva landscape.

Team

Lead: The Maryland Association of Soil Conservation Districts (MASCD) will be the lead on this solution. Lindsay Thompson, Executive Director, lindsay.mdag@gmail.com, 443-262-8491. Thompson will be responsible for coordination of the project as well as communication with the soil conservation districts and project partners in our target landscape.

Members: Other team members for this solution include:

- Dr. Gurpal Toor, Nutrient Management and Water Quality Specialist, University of Maryland; Dr. Toor has experience in water quality monitoring from working with the University of Delaware, University of Arkansas, and the University of Florida. Dr. Toor will be collecting and analyzing the data generated by the nutrient sensors.

- Danielle Bauer, Maryland Grain Producers. Danielle Bauer is the Communications and Programs Director for the Maryland Grain Producers. She will be responsible for utilizing the information gathered and analyzed by Dr. Toor to create informational materials and conducting outreach to producers.

- Soil Conservation Districts (SCDs). The Maryland SCDs will be responsible for outreach to producers and promotion of the practices being researched in the project.

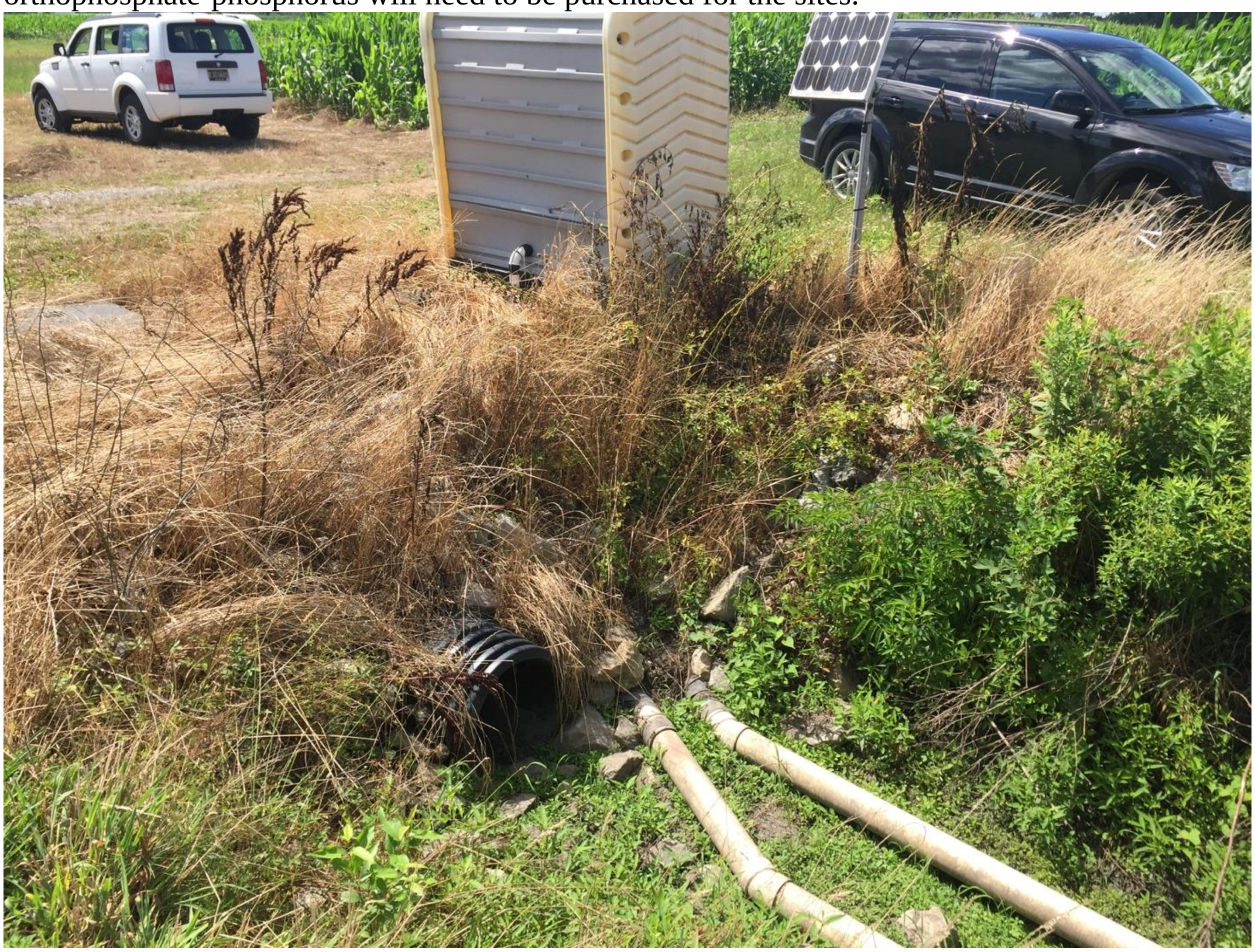
- Maryland Department of Agriculture. The Maryland Department of Agriculture will utilize the data to improve the information being used to determine the efficiencies of these practices in the Chesapeake Bay Model as well as inform their cost share decisions.

Sensors and Monitoring

Current Monitoring: Previous monitoring of drainage ditches was conducted by Dr. Joshua McGrath from August 2009 to August 2013 while working for the University of Maryland. This monitoring was comprised of six paired sites located on the Eastern Shore of Maryland and focused on progressive management practices for drainage systems. These sites have been shut

down since Dr. McGrath left the University of Maryland. These six sites are spread out on the Eastern Shore and represent parts of mid to lower shore agricultural drainage landscape. At each of the sites, the instruments installed on drainage ditch include an autosampler to collect water samples from the drainage ditches (Teledyne 6712 auto sampler), flow meter to measure water flow (Teledyne 720 Submerged Probe Flow Module), and rain gauge to determine the amount, intensity, and duration of rainfall (Teledyne 674 Rain Gauge). All of the instruments are contained in weather-proof boxes. These systems are powered using a custom solar panel and battery system. The data is retrieved using the Flowlink monitoring software. In nutshell, there are 24 autosamplers, 24 flow meters, and 24 rain gauges at these six sites.
We recently inspected these sites (August 2017) and observed that all instruments are intact and can be restarted with routine maintenance. For this proposal, we propose to use two of these sites where we will deploy two low cost nutrient sensors. These sensors will allow us to determine nitrate-nitrogen and orthophosphate-phosphorus concentrations at high-frequency (~30 minutes intervals, with up to 48 analyses in a day). These high-frequency analyses will allow us to determine how N and P are lost from land over storm events, providing critical insights on processes and mechanisms driving nutrient losses. This information will be critical in developing practices that reduce N and P losses and protect water quality in the Chesapeake Bay.

Future Monitoring: The team plans to use two of the existing sites and associated infrastructure installed on sites. New low cost continuous nutrient sensors for nitrate-nitrogen and orthophosphate-phosphorus will need to be purchased for the sites.



The above picture shows a drainage ditch that collects runoff and subsurface flow from agricultural fields. The weather-proof box contains auto-samplers, flow meter, which are powered by a solar panel.

Placement of Sensors: The low cost sensors will be deployed in conjunction with auto-samplers so that a part of the runoff is diverted to the sensors at regular intervals (~30 minutes intervals after beginning of a storm event) for analyses.

Power Considerations: The existing solar panel and battery systems will be used to power the sensors. If needed, an additional battery can be housed in the weatherproof box.
Sensor Maintenance: Regular maintenance and site visits (at least weekly) will be conducted to ensure that all instruments are working.

Telemetry: The current system does not have telemetry setup, but it is possible to configure the system with additional investment.

Calibration: In the beginning of deployment of low cost sensors and routinely thereafter, water samples will be retrieved from the auto-samplers, brought in the laboratory for analyses, to determine the goodness of fitness of low cost sensors. We will use standard methods to calibrate and validate nutrient sensors.

Sampling Regime: We propose to analyze samples with nutrient sensors after a significant rainfall event. We anticipate capturing 15-20 storm waters in a year at each site. We would use existing monitoring setup to collect additional samples, which will be subjected to detailed analyzes of various forms of N and P in the laboratory. The rain gauge would allow us to determine amount, intensity, and duration of rainfall events.

Data

Solution Architecture: We will retrieve data from nutrient sensors on at least a weekly interval. A USB drive will be used to download the data, which will then be imported into Flowlink software. Additional analyses on collected water samples along with detailed information about rainfall (amount, intensity, duration) and flow characteristics (minutes, hours, daily) will be imported into the Flowlink software as well. With some investment, it is possible to use telemetry for remotely accessing and downloading the data.

QA/QC: We will develop a QA/QC plan that will be include routine calibration, data validation by using external standards, replicates. The sensor collected data will be complemented with laboratory analyses to ensure collection of high quality data.

Data Sharing: We will use the proposed “Open Geospatial Consortium” data standards. The data will be shared at conferences and used in peer-reviewed articles.

Metadata: We will be NWQMC Water Quality approach (https://www.ioos.noaa.gov/wp-content/uploads/2016/04/national_water_quality_monitoring_council_elements.pdf) to explain the data content.

Analytics and Interpretation

The data will be visualized and analyzed using Flowlink software. Additionally, statistical tools such as SAS and/or R will be used. These approaches will allow us to determine significance of differences within and between storm events and will provide insights on nutrient transport from land to water.

Communications and Use

The information gained from this effort will be communicated with various agencies in the region including but not limited to EPA Chesapeake Bay Program, Maryland Department of Agriculture, and Soil Conservation Districts. Results will also be communicated using University of Maryland Cooperative Extension Channels (Dr. Toor is a State Extension Specialist) to farmers, crop consultants, nutrient management advisors.

The ultimate goal is to provide knowledge and information to be used in the Chesapeake Bay Program in order to inform the expert panel that will be making recommendations on accounting for ditch management practices in the Bay Model. Additionally, information on the efficiency of these practices will be communicated to the decision makers at the Maryland Department of Agriculture to inform their decisions on cost sharing of practices. These efforts will ensure that practices developed from this project are used by farmers in the fields and are integrated into the policy decisions in the region.