PHOSPHORUS MANAGEMENT TOOLS IN VIRGINIA, MARYLAND AND PENNSYLVANIA

CHESAPEAKE BAY COMMISSION · DECEMBER 2015

Phosphorus is an essential nutrient necessary for plant growth. Adding phosphorus to soil low in plant-available phosphorus promotes root growth and winter hardiness, stimulates new growth, and often hastens maturity. Plants deficient in phosphorus can be stunted in growth. In excess, phosphorus becomes a water quality concern. It is one of the three top pollutants to the Chesapeake Bay, subject of a Total Maximum Daily Load pursuant to the federal Clean Water Act. Managing phosphorus properly matters.

Most agricultural soils in Maryland, Virginia and Pennsylvania have ample phosphorus as a result of historical fertilization. Poultry litter and livestock manure, which are rich in phosphorus, are also plentiful in regions with substantial animal agriculture.

When commercial fertilizers are used to grow crops, the farmer's application rate and timing can and should be quite exact. In particular, rates of phosphorus and nitrogen can be adjusted to meet crop needs without over-applying either nutrient. Furthermore, the price of fertilizer tends to discourage over-application. However, when litter or manure are applied as fertilizer at rates based on a crop's nitrogen needs, it results in over application of phosphorus for that same crop. Timing and method of application are also critical to effective use of litter or manure as fertilizer.

The fate of phosphorus in soil is complex. Phosphorus binds to soil particles, reducing its mobility in water to some extent. For this reason, soil erosion was historically seen as the principal concern to non-point source phosphorus pollution. Most soils have the capacity to hold large amounts of phosphorus, but this binding capacity can diminish with certain soil characteristics (e.g., sand content) as well as with repeated manure or fertilizer phosphorus application. After several years of phosphorus application that exceeds the amount removed by the harvested crop, the soil's capacity to bind phosphorus is increasingly saturated, allowing for more water soluble phosphorus to be present in the soil. These water soluble forms have a higher potential to be lost to runoff waters. Reversing these processes can take many years and even decades.

In the Chesapeake region, the potential for soil erosion, phosphorus leaching, and runoff from agriculture is considered a significant water quality concern, but one that can be addressed with prudent management. For instance, state nutrient management guidelines and industry-derived initiatives, such as the "4 R" Nutrient Stewardship Approach (Right rate, Right method, Right timing, Right form)[1], all highlight practices that, in total, can reduce the potential for phosphorus transfers from farm land to the Chesapeake Bay. A key outcome of these guidelines is to identify field conditions where manure or fertilizer should not be applied due to water quality concerns.

State phosphorus indexes are the primary tool used to promote balanced management of phosphorus for crop production and water quality protection. Phosphorus indexes quantify the potential of a farm field to lose phosphorus to runoff by evaluating a combination of soil phosphorus, fertilizer and manure application, field management practices, environmental conditions, landscape and hydrologic (water transport) characteristics. Based upon this evaluation, states provide recommendations on phosphorus management options.

The scientific understanding of how to best evaluate and manage phosphorus continues to evolve. Not surprisingly, there is strong interest in revising state-specific phosphorus indexes to reflect improved understanding of a complex issue. For instance,

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1. This was started by IPNI, the International Plant Nutrition Institute and embraced by universities and government as an educational tool. http://www.nrcs.usda.gov/wps/portal/nrcs/main/national/landuse/crops/npm/

TABLE 1 Defining Features of the Risk Assessment Tools

	MARYLAND PMT	MARYLAND PSI	VIRGINIA PI	PENNSYLVANIA PI
During what year was the phosphorus risk assessment tool last updated?	2013	2005	2005	2007
At what soil phosphorus level is a phosphorus risk assessment tool triggered (shown in Mehlich-3 P)?[1]	Soil Test Phosphorus of 150 ppm or greater	Soil Test Phosphorus of 150 ppm or greater	Soil Test Phosphorus of 127 ppm or greater[2]	Soil Test Phosphorus greater than 200 ppm; distance to water < 150 feet; special protection watershed; or winter applications
Does the phosphorus risk assessment tool allow for nitrogen-based manure application?	No[3]	Yes	Yes[4]	Yes
What factors are used to assess sources of phosphorus?				
Soil phosphorus saturation	Yes	No	No	No[5]
Soil test phosphorus (same as that used for crop recommendations)	All Yes			
Form of applied phosphorus (commercial/organic)	All Yes			
Application rate, method and timing	All Yes			
What factors are used to determine transport of phosphorus?				
Erosion/soil loss[6]	All Yes			
Distance to surface water	All Yes			
Presence of a buffer	All Yes			
Subsurface drainage	All Yes, but metrics are dramatically different[7]			
Priority of receiving water	No	Yes	No	Yes

1. Each state uses a different soil test method. Conversions were made to show each value in the Mehlich-3 soil test value.
2. Virginia prohibits application of phosphorus to soils exceeding 65 percent phosphorus saturation levels. In addition to the PI, Virginia offers use of the Environmental Threshold Method to determine allowable phosphorus application rates for organic fertilizer.
3. It should be noted that in most cases, allowing an application rate of 3 years crop phosphorus removal is approximately the same as an application rate based on crop nitrogen needs.
4. While Virginia allows phosphorus application rates based upon crop nitrogen needs, such application is made only under low risk situations.
5. Phosphorus saturation is under consideration for Pennsylvania's next version of the PI. Additionally, under Pennsylvania's current PI, phosphorus saturation is strongly correlated with the required Mehlich-3 soil test.
6. Soil loss is determined using the USDA Revised Universal Soil Loss Equation (RUSLE) or RUSLE2 or an alternative option in Virginia is the Erosion Risk Assessment Procedure. RUSLE takes into account slope, soil type and texture, cropping history, rainfall and other factors.

TABLE 1 Defining Features of the Risk Assessment Tools (continued)

	MARYLAND PMT	MARYLAND PSI	VIRGINIA PI	PENNSYLVANIA PI
Soil permeability and drainage class	All Yes			
What phosphorus application is allowed for each risk assessment ratings?[8]				
If the P loss rating is less than 30 , phosphorus is applied at ...	3-year crop P removal[9]	N-based manure application	N-based manure application	N-based manure application
If the P loss rating is between 30 and 50, phosphorus is applied at ...	3-year crop P removal	N-based manure application	1.5-year crop P removal	N-based manure application
If the P loss rating is between 50 and 60, phosphorus is applied at ...	Crop P removal	3-year crop P removal	1.5-year crop P removal	N-based manure application
If the P loss rating is between 60 and 75, phosphorus is applied at ...	Crop P removal	3-year crop P removal	Crop P removal	N-based manure application
If the P loss rating is between 75 and 100, phosphorus is applied at ...	Crop P removal	Crop P removal	Crop P removal	Crop P removal[10]
If the P loss rating is >100, phosphorus is applied at ...	No P application allowed	No P application allowed	No P application allowed	No P application allowed
What are the primary drivers of the phosphorus risk assessment tool?	Phosphorus saturation, soil test, distance to surface water, buffer, slope, location	Soil test, distance to surface water, buffer, slope, location, sensitive waters, P application	Location, slope, land use, cropping system	Soil test, soil loss, P application rate and method, distance to water, buffer
What are the phosphorus risk assessment tool's strong points?	Method accounts for phosphorus saturation in soil and is capable of detecting high risk of phosphorus loss from a single pathway of loss (surface, subsurface, erosion).	Educational tool to encourage BMP implementation for sites with PI ratings of high or very high.	Assessment scores allow for additional P application restrictions.	Initial screening takes into account distance to water and quality of receiving waters; the tool has a very strong research foundation.

7. Each state evaluates subsurface drainage; however, each approach is significantly different and the Maryland PMT provides the most current understanding of this pathway.

8. Phosphorus risk assessment scores are categorized as Low, Medium, High and Very High. Each state defines these categories differently.

9. See footnote 4.

10. For the Pennsylvania PI, a phosphorus loss rating of 80 to 99 is considered high and calls for nutrient application at phosphorus crop removal.

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Maryland adopted a new phosphorus index, termed the Phosphorus Management Tool[2] (PMT), in June 2015. A distinctive feature of Maryland's revised tool is the separate assessment of the risk of phosphorus loss by each transport pathway. This is particularly important for the evaluation of phosphorus loss from the coastal areas of Maryland where phosphorus loss by shallow groundwater is a unique concern that is not covered by conventional assessments of surface runoff and erosion. The PMT also incorporates the concept of soil phosphorus saturation, improving insight into soil phosphorus contributions to field losses.

Opportunities exist for other states in the Chesapeake Bay region to update their phosphorus indexes. Virginia's phosphorus index was last revised in 2005. Nutrient Management experts in Pennsylvania and Virginia, along with West Virginia, Delaware, and New York, are currently involved in a regional USDA Conservation Innovation grant to better develop the scientific underpinnings of the phosphorus index. The goal of this regional collaboration is to ensure that the state phosphorus indexes are using up-to-date science to assess risk of phosphorus loss and to promote consistency, at a minimum, within physiographic regions (Allegheny Plateau, Ridge and Valley, Piedmont, and Coastal Plain).

In an effort to educate policy makers, Table 1 was developed to explore current differences between Maryland's existing Phosphorus Site Index (PSI) and the new PMT, Pennsylvania's Phosphorus Index (PI), and Virginia's PI. Understanding the differences can be instructive as each state considers future changes in their phosphorus management tools.

Restoration of Chesapeake Bay requires substantial reductions in nitrogen, phosphorus and sediment pollution from urban development, wastewater, and agriculture. The Chesapeake Bay Commission developed this report to assist our member states and their academic partners as they consider revisions to their indexes to reflect current science, experience using existing tools and required reductions in Bay phosphorus levels. In particular, states need to consider issues such as how their P Index addresses:

- artificial drainage (tile drains and open ditches);
- manure spreading on snow-covered or frozen ground;
- erosion estimation over a single year or a crop rotation; and
- soil phosphorus measurement.

As any state develops policies to reduce the risk of phosphorus loss from manure and litter, the state must also consider the viability of manure management options, such as transport, storage, and uses other than land application.

Chesapeake Bay Commission
Policy for the Bay

ABOUT THIS REPORT

This report was assembled by Commission staff based upon a review of each state's tools and from Fong *et al.* (2014).[3] The Chesapeake Bay Commission sought critical input and review from the region's leading soil scientists and agriculture nutrient management experts. We are indebted to them for their assistance in the development of this policy paper.

- Douglas Beegle, *Penn State University*
- Frank Coale, *University of Maryland*
- Peter Kleinman, *USDA Agricultural Research Service*
- Tim Sexton, *Virginia Department of Conservation and Recreation*
- Tom Simpson, *Aqua Terra Science*

2. The PMT will be phased in over seven years. The current Phosphorus Site Index will be used to guide fertilizer, manure and litter application on all farms in Maryland until 2018 when the PMT will be applied to the farms with highest soil Fertility Index Value (FIV) scores. By 2022 to 2024, the PMT will be the guiding tool for phosphorus management on all Maryland farms.

3. "A Comparison of New and Old Maryland Phosphorus Site Indices and Similar Indices from Adjoining Chesapeake Bay Watershed States," by Stephanie Fong, Ron Korcak, and Thomas Simpson, 2014, found at *http://waterstewardshipinc.org/wp-content/uploads/2014/08/Capstone_Final-Report.pdf.*