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Phosphorus Saturation versus the New York P Index? Impact on Manure and Fertilizer Management in New York State

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Introduction

Phosphorus enrichment of surface waters leading to algal blooms and other issues related to eutrophication continues to be an issue in a number of locations. Runoff from agricultural fields can contribute to P runoff and management tools and policies have been developed to manage runoff risk. In 1999, New York (NY) introduced its first Concentrated Animal Feeding Operation (CAFO) Permit. This was followed by release of the NY Phosphorus Index (NY-P Index; USEPA, 1999; Czymmek et al., 2003) and establishment of a statewide on-farm research partnership in 2001. State policy requires implementation of the Natural Resources Conservation Service (NRCS)-NY 590 nutrient management standard on all farms with a CAFO Permit as well as animal feeding operations (AFOs) receiving state or federal cost share funds for manure storage and other related practices. Since 2001, the NY-P Index has been a required element of the NY 590 nutrient management standard.

In May of 2009 President Obama signed an Executive Order to intensify efforts to protect and restore the Chesapeake Bay and its watershed. This Order resulted from the belief that there had not been sufficient progress in restoring the health of the Bay and its watershed in the past 25 years. As a result of the Order, USEPA published *Guidance for Federal Land Management in the Chesapeake Bay Watershed* ("Guidance document") on May 12, 2010. This document states that managing P through state-based P runoff indices is flawed and results in over-application of P to cropland. In the Guidance document, USEPA replaced the P index approach with a Psat approach based on a 20% Psat cutoff for manure or fertilizer application (USEPA, 2010) (Figure 1). While only applicable on federal lands at this point, it is viewed by some as a potential precursor to more widespread implementation on private lands.

Guidance for Federal Land Management in the Chesapeake Bay Watershed by USEPA:
Base P application on P saturation in soils as follows:

- If the soil P saturation percentage is above 20 percent, do not apply manure or commercial fertilizer that contains P to cropland, grazing or pasture land.
- When soil P saturation percentage allows for application (i.e< 20%), apply up to an N-based rate.
- Also, implement a soil P monitoring plan to ensure that soil P levels are staying steady over time.
- If soil P saturation percentage is increasing, adjust manure applications to P based rate and use commercial N fertilizer to make up the difference; if levels exceed 20 percent P saturation, no longer apply P.

Figure 1. Guidance for Federal Land Management in the Chesapeake Bay Watershed: 1.2.2 Implementation Measures for Agriculture in the Chesapeake Bay Watershed to Control Nonpoint Source Nutrient and Sediment Pollution, USEPA.

During the review period for the Guidance document, USEPA received input from numerous organizations, including academic members of SERA-17. This group consists of research scientists, policy makers, extension personnel, and educators with the mission to develop and promote innovative solutions to minimize P losses from agriculture by supporting: (1) information exchange between research, extension, and regulatory communities; (2) recommendations for P management and research; and (3) initiatives that address P loss in agriculture (http://www.sera17.ext.vt.edu/). The SERA-17 scientists questioned the validity of the use of a Psat based cutoff for land application of manure and/or fertilizer, raised concerns that the Psat approach does not consider landscape position (a critical component of P loss), and pointed out that various Psat methodologies provide significantly different results. Despite these comments, USEPA published the 20% Psat cutoff in the Guidance document (http://www.epa.gov/owow_keep/NPS/chesbay502/pdf/chesbay_responsetocomments.pdf):

> "EPA recognizes that Psat is an important feature that could improve the usability of the P index in long term nutrient management planning, particularly where P leaching is the primary environmental concern. EPA does not recommend any one methodology for determining Psat. We understand that the methods used to determine Psat are depended upon the chemical features of the extracts and do not provide conversion factors between the methods mentioned. EPA understands that the method of P analysis should always be clearly described in any presentation of Psat or soil test P. Also, while Psat and soil P are correlated, by determining the P application based on P-Sat, EPA's recommendation will still allow application beyond realistic yield goals in areas where Psat is lower than 20 percent; soil P is a more conservative estimate for P applications."

The implementation of the Psat cutoff for P application to federal land, and the potential for implementation of a similar cutoff for all agricultural land, motivated a project to compare the impact of use of a Psat approach on P fertilizer and manure application cutoffs as compared to our current NY P index approach. Specifically, our goal was to evaluate if a Mehlich-3 derived Psat (P/[Fe+Al]) could be converted to a particular Cornell Morgan P and if so, determine the potential 20% Psat cutoff for manure application.

What Did We Do?

In total, 91 soil samples were tested for Cornell Morgan (Morgan, 1941) and Mehlich-3 (Mehlich, 1984) extractable P, Fe, Al, and Ca. The Psat was determined as P/[Fe+Al]*100 (molar ratios) according to Kleinman et al. (2002). As mentioned, there are different methods for estimating Psat. The ratio of Mehlich-3 extractable P over Fe+Al was selected as a most likely candidate for implementation, because it is a commonly available agronomic test, despite evidence that this method (1) is unsuitable for calcareous soils found in parts of NYS, and (2) requires soil specific calibrations. Samples were collected from New York farms identified in conjunction with Agricultural Consulting Services, Inc. (ACS). Samples were air-dried and ground to pass a 2 mm sieve prior to laboratory analysis. Regression analyses were performed to determine if Morgan data could be correlated to Psat and if so, at what Cornell Morgan soil test level a Mehlich-3 derived P saturation of 20% was obtained.

What Did We Find?

Across all soil samples, a P saturation of 20% corresponded to a Cornell Morgan P of 86 lbs/acre (Figure 2). This Cornell Morgan value was somewhat higher than the 56 lbs P/acre

(Cornell Morgan test) reported for 59 soil samples from the Delaware River Watershed in 1999 (Kleinman et al., 1999; assuming that Psat based on Mehlich-3 equals 0.7 times Psat derived from the oxalate extraction according to Kleinman and Sharpley, 2002), and similar to the 80 lbs P/acre (Maine Modified Morgan test) for 106 soil samples submitted to the Maine Soil Testing Service (Ohno et al., 2007). The New York data also show a wide range in soil test P equivalents; for example, of the 7 soils with a Psat of 20%, corresponding Cornell Morgan P levels ranged from 56 to 172 lbs P/acre with a median value of 71 lbs P/acre. Similarly, soils with a Cornell Morgan P of 75-85 lbs/acre corresponded to a Psat ranging anywhere from 16 to 38%.

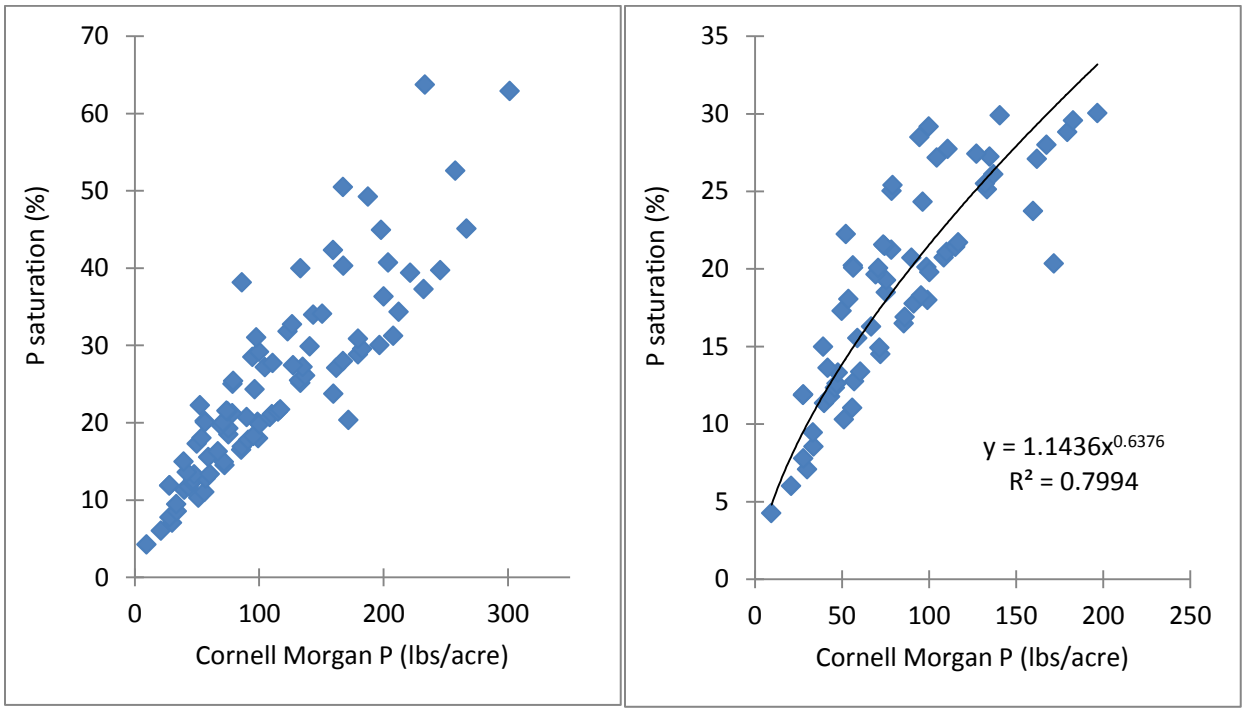

Figure 2: Relationship between the Cornell Morgan P test and P saturation derived from Mehlich-3 data (P/(Fe+Al) in molar ratio).

Implications

The implementation of a Psat cutoff of 20% for manure application instead of the NY-P Index will not impact manure application to high risk fields with a Cornell Morgan soil test of 80 lbs/acre or more, as the current P Index will not allow manure application to those fields as the NY-PI score will be 100 or more if the the transport factor is 1.0. Given that a very low percentage of NY fields test greater than 80 lbs P/acre (about 5%), implementation of a Psat in NY will have minimal effect on manure application practices. However, it could adversely impact farms with fields with very high soil test P but low transport risk. Such Psat based policy purports to address manure disposal (i.e. application beyond what would be most optimal for P resource management) but will increase the use of purchased fertilizer as it does not account for fertilizer value of N and K in the manure. Further, we do not believe implementing the Psat cutoff in NY offers real environmental benefit because as a chemical test alone, it fails to account for key, field specific risk considerations of landscape position and relationship of the field to surface waters.

Conclusions

Implementation of a Psat approach will cause restrictions on P application for very high P fields with a low NY-PI transport risk. On average, across all soils in the study, a Psat of 20% corresponded to a Morgan soil test P level of 86 lbs/acre, just above the current cutoff for P application for fields with a high transport risk. This means that implementation of a Psat approach would eliminate manure and fertilizer application to fields with a Cornell Morgan P of 86 lbs/acre, *independent* of the risk of transport of this soil test P to surface or groundwater. We do not recommend the application of the Psat approach in NY as it will increase costs for some farms while unlikely to offering corresponding environmental benefit.

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