


Phosphorus Runoff Loss Risk Assessment for Unincorporated Manure Applications

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Introduction

The Wisconsin Phosphorus (P) Index is a field-level runoff P loss risk assessment tool for evaluating agricultural management practices. It assigns an annual risk ranking to a field by estimating annual P loss to the nearest surface water. The P Index considers dissolved P (Soluble P Index) and sediment-bound P (Particulate P Index) loss. Unincorporated manure applications increase the potential for P in runoff. Runoff experiments with surface manure applications have shown that the proportion of rain converted to runoff greatly influences both runoff dissolved P concentrations and P loss. Accounting for the likelihood of runoff following a manure application is a challenge for a P index. This poster describes the method developed to do this for the Wisconsin P Index.

The Challenge: How to estimate P loss in runoff following recent manure applications

Nearly 600 runoff trials conducted in WI since 1998 show soil test P controls runoff dissolved P concentrations when no manure has been applied for at least 6 months (Fig.1) (Andraski, 2007). Therefore for such conditions, the WI P Index estimates runoff dissolved P loss using empirical relationships with soil test P and an estimate of runoff volume.

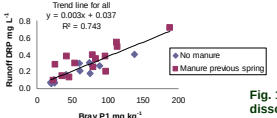

Fig. 1. Soil test P and runoff dissolved P without recent manure applications

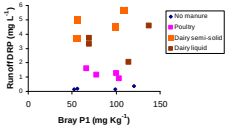

Fig. 2 Soil Test P and runoff dissolved P within 7 days of manure application

When manure has been recently applied, soil test P no longer controls runoff dissolved P (Fig. 2). For these conditions, an important determinant of runoff dissolved P was the proportion of rain converted to runoff (Fig. 3).

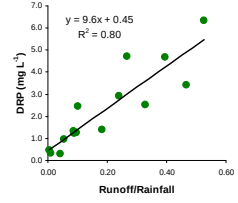

Fig. 3. Runoff/Rainfall and dissolved runoff P following manure applications Data are from across WI, 1998 to 2006. Soil conditions and manure types, P content and application rates varied. All trials received (75 mm) of rain over 1 h.

Source: J. S. Studnicka, T. W. Andraski, L.G. Bundy, L. W. Good, and J. M. Powell, unpublished data.

The Method: Estimating runoff dissolved P following manure applications

The WI P Index is part of a fertilizer and manure application planning software package, Snap-Plus, that also estimates soil erosion using RUSLE2. Snap-Plus users enter the rate, type, method and season of planned manure applications. The P Index then estimates runoff dissolved P loss from unincorporated manure using a formula adapted from the manure P runoff model of Vadas et al, 2007. This formula assumes precipitation leaches all water-soluble P in surface-applied manure during the season of application. The formula partitions a portion of that leached manure P to runoff based on the runoff-to-rain ratio for that season.

Manure Dissolved P = Manure SP x Runoff/Precipitation x PD Factor

Manure SP: **manure water-extractable P on the surface. Snap-Plus contains water-solubility factors for manures by species and handling systems.**

Runoff: **runoff volume for the season of manure application. For the frozen-soil period, runoff is estimated using 10-year mean values from agricultural watersheds with similar soils. Runoff estimates are modified based on fall tillage to account for surface roughness. Spring, summer, and fall runoff are estimated using curve numbers generated by RUSLE2.**

Precipitation: **20-year mean precipitation volume for the season of manure application.**

PD Factor: **determines how much of the P leached from surface manure by rain is actually transported in runoff. It is calculated as (Runoff/Rainfall)$^{0.225}$ (Vadas, 2007)**

More information on the factors in this equation and the data used to develop them can be found under "Calculations" at http://wpindex.soils.wisc.edu/

References:

Andraski, T. A. 2007. Simulated Rainfall Runoff Study Methods. At www.soils.wisc.edu/extension/nonpoint/.

Bonilla, C.A., D.G. Kroll, J.M. Norman, D.C. Yoder, C.C. Molling, P.S. Miller, J.C. Panuska, J.B. Topel, P.L. Wakeman, and K.G. Karthikeyan. 2006. Instrumentation for measuring runoff, sediment and chemical losses from agricultural fields. J. Environ. Qual. 35(1):216-223.

US Geological Survey. 2007. USGS Real-time water data for Wisconsin. http://waterdata.usgs.gov/wi/nwis/rt/

Vadas, P.A., W.J. Gburek, A.N. Sharpley, P. J. Kleinman, P. A. Moore, Jr., M. L. Cabrera, and R. D. Harmel. 2007. A model for phosphorus transformations and runoff loss for surface-applied manures. J. Environ. Qual. 36:324-332.

Sources of field management and runoff monitoring research data: Dave Owens, Todd Stuntebeck, and Matt Komiskey, USGS; Carlos Bonilla, John M. Norman, and Christine Molling, Jeff Topel, UW Dept. of Soil Science; Randy Mentz and Chris Baxter, UW-Platteville Pioneer Farm; Kevan Klingberg, Eric Cooley, and Dennis Frame, UW Discovery Farms.

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The Test: Comparing measured and estimated P runoff yields

Location of farms with monitored fields

To determine if the equation ranks runoff P loss risk from manure applications appropriately, we compared P Index results to runoff P losses for 17 in-field sites monitored from 2004 through 2006 (Bonilla et al, 2006; US Geological Survey, 2007). Fields are on farms in different regions of WI and vary in soil type and management.

Precipitation and runoff varied by year across sites (Fig. 4). Spring and summer runoff was high in 2004. In 2005, most runoff was from snowmelt or rain on frozen ground. In 2006, both frozen and non-frozen soil runoff was low or did not occur.

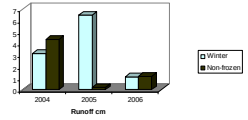

Fig. 4. Mean runoff volume by frozen and non-frozen soil period for 17 cropped fields in Wisconsin, 2004-2006.

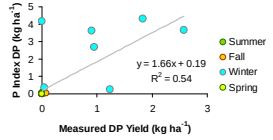

Fig. 5. Measured and P Index-estimated dissolved P loss using average weather and runoff values.

The P Index appropriately ranked dissolved P losses from manure using long-term weather and runoff averages (Fig. 5). Winter applications had the highest estimated and measured P loss. Some error in P loss estimations was due to using average weather and runoff values instead of field-measured values. When estimating P loss using field-measured weather and runoff values, these errors were eliminated (Fig. 6). The strong relationship between measured and calculated yields indicates the equation estimating seasonal manure P loss in runoff is valid.

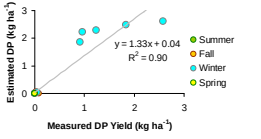

Fig. 6. Measured and P Index-estimated dissolved P loss using measured rainfall and runoff values.

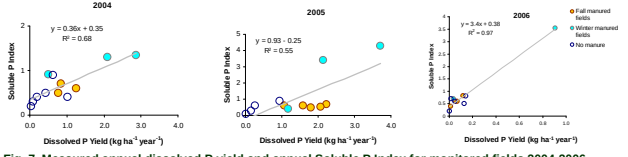

Fig. 7. Measured annual dissolved P yield and annual Soluble P Index for monitored fields 2004-2006.

In the P Index, estimated dissolved P runoff loss from unincorporated manure is combined with dissolved P loss from the soil for the annual Soluble P Index. Figure 7 shows that the P Index is accurately ranking dissolved P losses from unincorporated manure in relation to dissolved P losses during other parts of the year for fields with and without manure applications.