IMPACT OF MANURE APPLICATION IN DIFFERENT SEASONS ON PHOSPHORUS LOSS IN RUNOFF

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Introduction

Agricultural nutrient management continues to be an important area of research and policy due to concerns of phosphorus (P) loss in runoff and water quality degradation. Surface manure application to fields without incorporation can be a significant source of P loss (Daniel et al., 1998). In many northern states, winter manure application without incorporation is common (Srinivasan et al., 2006). This fact, combined with frequent snowmelt runoff, has prompted some states to restrict winter manure spreading. However, restrictions are based more on commonly held perceptions than on research. Studies of winter manure P loss are limited, and most have been observational with mixed results (Kongoli and Bland, 2002). P transport from winter-applied manure varies due to infiltration, runoff, erosion, and nutrient cycling processes, all of which are sensitive to air and soil temperatures. Manure P loss also varies with spreading practices, especially relative to manure placement beneath or on top of snow and the effect of manure on rates of snow melt (Williams et al., 2011). Overall, good understanding of P cycling and transport associated with winter manure application is still lacking.

There is an increasing demand to evaluate all agricultural systems where non-point P pollution is a priority. Relying on physical monitoring is too costly and time-consuming, so models have been developed to simulate and assess those management and process interactions that cannot be physically investigated. Vadas et al. (2007) developed the SurPhos model to predict dissolved P loss in runoff from surface-applied manures (Figure 1).

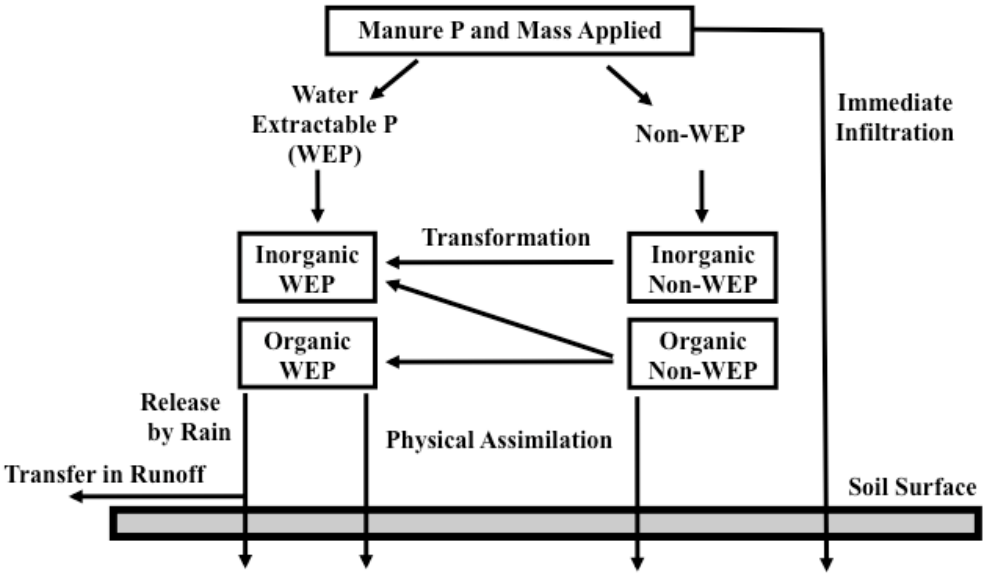

Figure 1. Schematic of the SurPhos manure P runoff model.

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SurPhos is a daily time-step, process-based model that simulates manure application to the soil surface, dry matter and P transformations (e.g., organic matter decomposition, organic P mineralization) as manure ages in the field, physical assimilation of manure into soil by bugs, leaching of P from manure during rain events, and loss of manure dissolved P in runoff when runoff occurs.

The USDA-ARS and the UW-Madison have a collaborative research project that is investigating the physical and chemical processes controlling P loss in runoff from winter-applied dairy manure. As part of that project, we are using the SurPhos model to help estimate how the day of manure application influences P loss in runoff. We are specifically trying to quantify how much greater the risk of manure P loss is from winter-applied manure compared to manure applied in other seasons. To do this, we collected real precipitation and field runoff data from six monitored locations in WI. In total, there were 108 site years of runoff data representing a variety of climate and soil conditions. We divided the data into three groups of high, medium, and low runoff based on how much runoff was observed during the winter period (mid-November through mid-March). We then used SurPhos to simulate a liquid dairy manure (6% solids) application of 10,000 gallons/acre, or 35 lbs total P/acre. We allowed the model to change the day of manure application so that each day of the year was represented. For example, the model was first run so manure was applied on October 1 on each year, with the model simulating about 35 years of runoff data. The results were then processed to determine an average rate of annual manure P loss in runoff. The model was then reset, and the process was repeated with manure applied on October 2, and so on until all days of the year were simulated. This entire process was conducted separately for low, medium, and high groups of runoff data

Results and Discussion

Figure 2 shows the results of the SurPhos manure P runoff simulations. P loss is generally low for all rates of site runoff if manure is applied between March and October. For the low runoff sites, P loss in runoff increases if manure is applied in the winter, but not very dramatically. For medium and high runoff sites, applying manure during the winter can significantly increase the risk of P loss, with peak loss occurring if manure is applied around late January to early February. The results show that avoiding winter manure application could help decrease potential P loss in runoff. Because the rate of runoff (high, medium, or low) is not always the same for a given field every year (i.e., the same field could have low runoff one year and high the next), it may be difficult to reliably identify low runoff fields that may be able to receive winter-applied manure.

Table 1 presents a summary of the effect of applying manure in winter (December-March) vs non-winter on P loss in runoff. These data are averages of P loss for all winter days or non-winter days. Results show generally that applying manure in the winter can increase P loss from 2.8 to 4.2 times, with the increase greater as the amount of runoff increases. High runoff sites have the potential to lose more than seven times the amount of P from surface applied manure as low runoff sites. Medium runoff sites would lose more than three times as much manure P as low runoff sites.

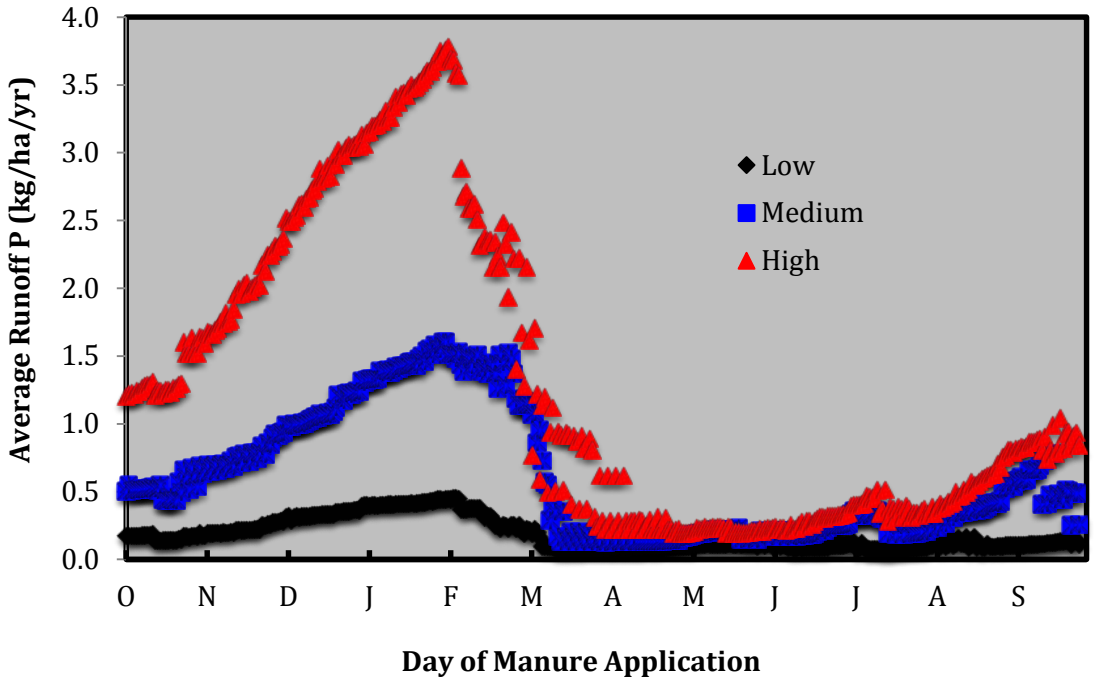

Figure 2. Model simulations showing the effect of manure application day on P loss in runoff for low, medium, and high runoff sites.

Table 1. Summary of the effect of applying manure in winter (December-March) vs non-winter on P loss in runoff.

Runoff Group	Winter P Loss (kg/ha/yr)	Non-Winter P Loss (kg/ha/yr)	Season Difference	Runoff Difference over Low
Low	0.33	0.12	2.8x	--
Medium	1.19	0.33	3.6x	3.4x
High	2.63	0.63	4.2x	7.2x

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