CHALLENGES IN IMPLEMENTING PHOSPHORUS BASED NUTRIENT MANAGEMENT PLANNING

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ABSTRACT. *The last decade has seen major research strides in the US, highlighted by efforts in Pennsylvania and surrounding states, to develop phosphorus (P) management strategies for protecting water quality in a sustainable animal agriculture production system. The most visible outcome of this effort has been the development of state of the art phosphorus site indices (P Index). The P Index has been adopted as a component of nutrient management policy or regulations in 47 states. While research on agricultural P and the environment continues, new efforts are currently under way focusing on implementation of P- Index based policies. Significant challenges have emerged as we have transitioned into implementation. These include fundamental questions about the underlying validity of the P Index and the relationships between regional nutrient balance and BMP-based approaches such as the P Index. Also, many operational challenges have been identified such as: costs and time required for P-Index based plans; variable implementation costs due to location and type of operation; integration of P- Index based plans with other plans such as farm conservation plans; and what BMPs are available to address problems identified by the P Index. Like many other areas, we in Pennsylvania and the Mid-Atlantic region have been working to evaluate and develop practical responses to these challenges. This paper discusses some of the key challenges we face and how we are responding. Examples of intra- and interstate collaboration to address technical and policy issues are also provided.*

Keywords. *Best management practices, eutrophication, manure management, nutrient management, phosphorus index, phosphorus runoff, water quality*

Phosphorus (P) is an essential element for crop and animal production. However, excessive P inputs to freshwater systems can result in accelerated eutrophication (Carpenter et al., 1998) making the water unfit for many uses. While there are many potential point and non-point sources of P affecting water quality, intensive animal agriculture has been identified as a primary source (USGS, 1999).

STRATEGIC ISSUES IN P MANAGEMENT

To effectively address the problem of agricultural non-point source P pollution, it is important to recognize that while individual farm nutrient management tactics are important, the root cause of the problem derives from the strategic organization of modern animal agriculture. Market based economics have produced an organizational pattern whereby animals are concentrationed on highly-specialized farms that are located separately from grain-producing areas where feed for the animals is produced. This has resulted in a major accumulation of excess nutrients in areas dominated by animal production (CSREES, 2004; Kellogg et al., 2000). At the same time, significant non-market forces arising from environmental concerns are providing negative feedback about nutrient management resulting in a collision of economic and social power (Lanyon, 2000). For instance, nutrient management plans written to protect water quality can have significant negative economic consequences for the farmer. Therefore, the tactical approaches used to address nutrient management issues, as discussed in this paper, must be considered in the context of this larger strategic picture. These approaches are important and should reduce the immediate water quality impacts of intensive animal agriculture, but they do not address the larger nutrient imbalance/surplus that ultimately drives the water quality problem.

APPROACHES TO P BASED MANAGEMENT

In 1999, the USDA and USEPA published a joint unified strategy for nutrient management (USDA/USEPA, 1999). This laid out a strategy for implementing comprehensive nutrient management plans (CNMP) on animal feeding operations in the US. The USDA/USEPA strategy provided three options for managing P in CNMPs: (1) Agronomic soil test based P management; (2) environmental P threshold soil test based P management; and, (3) P site index based P management. Sharpley et al. (2003) reported that 47 states have adopted the P Index approach as part of their CNMP process.

THE P INDEX APPROACH

The P Index is based on the concept of critical source area (CSA) management. P loss generally occurs from only a small part of a watershed (CSAs) during a few storm events (Pionke et al., 1997). Within a watershed, CSAs can be found in areas where a concentrated source of P coincides with a mechanism to transport the P to water. Thus, scientists studying P transport refer to “source” and “transport” variables as separate factors controlling P export from watersheds.

The P Index is a field evaluation tool that was developed to identify CSAs that have a high vulnerability or risk of P loss to surface water bodies. The concept of a P Index was originally proposed by Lemunyon and Gilbert (1993). Much research followed publication of this concept and current P indices are the outcome of a major international research and development endeavor to refine a management approach that protects water quality from P pollution and enables sustainable, economic animal agricultural production.

The P Index combines readily available indicators of P sources and P transport potential that determine P loss from agricultural fields. While there are differences between P indices across the country (Sharpley et al., 2003), commonalities abound and the Pennsylvania P Index can be viewed as a typical example. Source factors used in the Pennsylvania P Index (Weld et al., 2003) are Mehlich-3 soil test P; P fertilizer application rate and method; and manure P application rate, method, and P source availability coefficient. Transport factors include soil erosion, runoff potential, subsurface drainage, distance to a water body, and an evaluation of management practices that impact potential P loss from a field. These factors are combined in a simple calculation to arrive at a P Index value for the field that allows fields to be ranked on the basis of their vulnerability to P loss. The P Index value is used to determine whether the manure application rate may be limited and/or other management practices may be required to address P concerns. Other management practices may include installation of best management practices (BMPs) to reduce transport potential, such as common erosion control practices or buffers. Alternatively, changes in the time or method of manure application may reduce the risk of P loss to the point where manure can be applied.

The P Index is viewed as a practical, effective method of addressing P runoff related to manure applications because it P focuses on critical factors found to impact P loss. The index identifies those fields that are likely to affect water quality by the loss of dissolved and sediment-bound P and limits application rates or directs implementation of other management practices, as the situation warrants.

Challenges to P Index Implementation

While research on validating and calibrating the P Index and its components continues, efforts have begun across the country to implement the P Index in nutrient management planning. Several important challenges to implementing the P Index have been identified.

Operational Challenges

Government agencies that deal with nutrient management programs have generally accepted the concept of the P Index. However, even though the P Index has been developed to be a relatively simple tool for use by farmers, farm advisors and regulators, it has added an additional level of complexity to nutrient management planning. This has created resistance from some agency managers and regulators who are concerned with the added complexity, greater workload and additional planning costs associated with using the P index in nutrient management planning based programs. They would prefer simpler methods, such as soil test P threshold approaches, that are easier to implement in government programs, but are more difficult to implement and will result in more costly management alternatives that have been shown to be less effective in targeting P-based BMPs for effective water quality protection. Several things have been done to address these concerns. First, most states have recognized the critical need for education programs to train field personnel to use the P Index. Second, many states have adopted simple pre-screening tools to either identify areas most likely to require full P Index assessment or to eliminate areas that are unlikely to present a risk of P loss and thus reduce the number of fields requiring full P Index assessment. For example, in Pennsylvania fields with a Mehlich 3 soil test P level less than 200 ppm and that are at least 150 feet from water are considered low risk and thus do not require a full P Index assessment. While full P Index assessment might be desirable in all situations, the use of a pre-screening tool has been viewed as an acceptable compromise, at least in the short term, to target resources to areas most likely to require P based management.

A critical parameter in almost every P Index is an estimate of soil loss. The potential workload to calculate the estimated soil loss from the Revised Universal Soil Loss Equation (RUSLE) is a major concern in many states. In response, training for nutrient management planners in using RUSLE has increased. Also, several states are considering shortcut methods of doing RUSLE soil loss calculations. This is an area of significant ongoing debate. Fortunately, in many cases a current farm conservation plan exists which includes soil loss calculations. However, there are frequent problems with integrating conservation plans and nutrient management plans. For example, in Pennsylvania we have found that the definition of a “field” in a conservation plan is often different from how a “field” is defined in a nutrient management plan. For the planning process to be successful this difference must be resolved.

The use of computer software and GIS databases is frequently cited as critical to practical implementation of P Index based planning. Many states have or are developing software to assist with P Index assessments and integration of the results into nutrient management plans.

ECONOMIC CHALLENGES

Two major economic challenges to P Index management have been identified. First, is the added cost to develop a plan that includes the P Index. Significantly more data collection and calculations are required. In Pennsylvania, plan development assistance payments to farmers for developing P based plans have been almost doubled from what they were under N based planning. Of even greater concern is the cost of implementing P based plans. Weld et al. (2002) evaluated the management and economic impacts of implementing P based planning on a range of representative farms in Pennsylvania. In this study nutrient management plans were developed using the full P Index on all farm fields (no pre-screening was used). The results were that 23% of the fields that were assessed with the P Index required a P based management change. These changes ranged from simply altering the timing or method of an application to a complete ban on P applications in some fields. The combined total cost of first year P Index nutrient management plan implementation for all study farms was $45,380. However, the results were very site specific, varying from little or no economic impact on land extensive dairies to major negative economic impacts, some resulting in a negative net farm income, on some intensive swine and poultry operations.

TECHNICAL CHALLENGES

As the P Index has begun to be implemented several technical questions have come up. The first one goes back to a question raised earlier about "what is a field". The common approach used by NRCS to calculate soil loss using RUSLE is to look at management areas on a farm landscape that may include many fields. In this application of RUSLE, the soil loss calculated is an average for all fields, and different crops over the entire cropping rotation. However, as noted earlier in introducing the CSA concept, most P loss occurs from specific areas in a landscape during a few rainfall events. Consequently, manure applied to a specific field currently cropped to corn silage might have a much higher actual risk of P loss than would be estimated from using the average soil loss for the whole area over a long term rotation that includes forage crops. Thus, it would seem that soil loss for the P Index should be calculated for each field and for a given rotation crop. This has major workload implications and is currently the subject of research to determine how critical the approach used to estimate soil loss is to the validity of the P Index result.

A growing number of P indices include a P availability coefficient, more recently referred to as a P source coefficient (PSC). The PSC provides an indication of the relative solubility of P in different organic P sources, which is related to the dissolved P loss in runoff from surface applied manure. This parameter is especially important for materials that have been treated to reduce P solubility such as alum treated poultry litter and many biosolid materials. In the northeast, an effort is underway to develop a standard list of PSCs. Also, a routine laboratory estimate of water soluble P in organic materials has been developed that should enable estimation of PSC for specific materials (Wolf et al., in press).

Best management practices play a critical role in minimizing P loss to water. However, many BMPs have not been adequately evaluated for their effectiveness in reducing P loss. Also, many P Indices do not adequately address the impact of BMPs on the risk of P loss. This is both a research and implementation issue, which is being addressed at local and national levels (Conservation Effects Assessment Project, 2004; Sharpley et al., 2002).

MEETING THE CHALLENGES

These challenges are being addressed in many places. Major research and extension programs have been devoted to meeting these challenges so that we can adequately address P-related water quality concerns, but do it in a way that enables sustainable animal agriculture production. Several common threads run through the more successful efforts. First is interagency cooperation and collaboration. This includes university and ARS researchers, cooperative extension specialists and agents, federal agencies such as USDA, NRCS, and EPA, state environmental and agricultural agencies, and many private sector agricultural and environmental professionals.

Again using Pennsylvania as an example, there has been broad private and public participation in the P Index development and implementation process. The agriculture industry and local organizations have been ready and willing to field test P management approaches and provide constructive feedback. As questions have arisen, researchers have been quick to respond to try to determine answers, often with the help of state funding. In-turn, the results of this research have been rapidly integrated into education and policy development efforts. This collaboration must be very broad not only across organizations but also across geographical boundaries. In the Northeast, a very strong interstate, interagency collaborative effort has evolved which has been very effective in developing a strong P management program in the region. Finally, it is critical to educate stakeholders and policy makers so that they can make informed, science based decisions on P water quality issues and support practical and effective strategies such as using the P Index.

Conclusion

The use of the P Index as the basis for P based nutrient management planning has been demonstrated to be a sound approach to achieving water quality goals and sustainable agricultural production. While research continues to refine the P Index, new efforts are underway to address challenges identified as we begin to implement this approach. These include practical concerns with manpower and resource requirements both for P Index based planning and also implementation of these plans. Targeting using screening tools, and providing financial support and cutting-edge technology such as computer software are critical to addressing these concerns. Remaining flexible and maintaining an active link to research is important to tackle the inevitable technical questions that arise as we implement this new nutrient management strategy. Finally cooperation and collaboration amongst stakeholders, scientists, and government agencies is crucial to success.

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