THE PHOSPHORUS INDEX AS A NUTRIENT MANAGEMENT PLANNING TOOL

Purpose

The purpose of a phosphorus (P) index is to assess the risk of P delivery to surface waters. The index is a tool to help conservation planners, landowners/landusers and others to evaluate the current risk from P reaching surface water from a specific site, and to determine factors which dominate the risk due to P transport to surface waters. It will also assist landowners/landusers in making management decisions to reduce the risk.

Relating the P-Index to the Comprehensive Nutrient Management Plan (CNMP)

Each state NRCS was required to revise its nutrient management policies, guidelines, and standards by May 2001, which included the 590 Nutrient Management Standard. NRCS national policy and guidelines and the Environmental Protection Agency's proposed concentrated animal feeding operation (CAFO) rule require P planning both for NRCS CNMPs and EPA permit nutrient plans (PNP). Both the NRCS and EPA are allowing the states to select from three P-planning tools: soil-test P values, threshold limits, or the P-Index. The P-Index is the most comprehensive and scientifically based tool of the three options.

Background

Phosphorus is an important nutrient needed for crop production and many fertilizers and organic sources can be used to supplement the supply of available P in soils. However, there are environmental concerns when excessive amounts of P (and other nutrients) from various sources reach surface waters. Because manure is an unbalanced fertilizer compared to crop removal of nutrients, it is possible for P buildup in soils that are continually fertilized with manure at N-based rates. Phosphorus from soil, manure, fertilizer, and runoff, or subsurface flow that reaches surface water can produce eutrophication. Eutrophication is defined as an increase in the fertility status of natural waters that causes accelerated growth of algae or aquatic plants. In most fresh surface waters (lakes, ponds, and streams), the excessive growth of algae or aquatic plants is limited by inadequate levels of P. Large inputs of P to surface waters from nonpoint sources such as agricultural fields can elevate the P concentration in the water above critical levels for aquatic plant growth and thus enhance the development of eutrophication.

The P index is an integrated approach to estimating the risk of P delivered to surface water from agricultural fields. This tool was developed to assess the potential for P moving from individual fields based on selected soil and field characteristics and on management practices. The P index is much more comprehensive than relying only on soil test P because it integrates many soil and field characteristics that influence potential P movement to surface waters. These characteristics include source factors such as soil test P, total soil P, rate, method, and timing of P application (fertilizer, manure, and other organic sources), and erosion. They also include transport factors such as sediment delivery, relative field location in the watershed, soil conservation practices, precipitation, runoff and tile flow/subsurface drainage. The P index provides a relative rating as to the risk of P moving from individual fields, which can be used to prioritize fields for nutrient and soil management practices.

The Iowa P-Index

The following is a discussion of the components and factors of the Iowa P-Index. The Iowa P-Index and supporting documentation is available at the Iowa NRCS web site http://www.ia.nrcs.usda.gov.

1. Erosion Component (Potential P delivered to surface water with sediment):

Gross erosion x (Sediment trap factor or SDR) x Buffer factor x Enrichment factor x STP Erosion factor

Gross erosion is soil loss in tons/acre/year estimated using the NRCS Field Office Technical Guide (FOTG) to calculate soil loss using the revised universal soil loss equation (RUSLE), ephemeral gullies, and classical gully erosion procedures.

Sediment trap factor accounts for the sediment captured by certain conservation practices.

Sediment delivery ratio (SDR) is determined by major Iowa landform region (soil type) and distance of the field to a water body.

Buffer factor refers to a vegetative buffer that meets NRCS standards for filter strips. Three classes, arranged by buffer width are used.

Enrichment factor accounts for the increase in the proportion of fine soil particles in eroded sediment, which tend to have a higher concentration of P when certain land treatments are present. Five classes ranging from 1.1 to 1.3 according to cover or tillage utilized and presence or absence of a buffer strip are used.

Soil Test P (STP) Erosion factor represents the amount of particulate P in delivered sediment that likely will be released to the water over a long period of time. It is estimated as 70% of the total P concentration of the sediment, based on an average amount of total P (with low STP) in the surface 6-inch layer of soil and a recent measurement of STP.

2. Runoff Component (Potential P delivered to surface water in runoff):

Runoff factor x Precipitation x (STP Runoff factor + P Application factor)

Runoff factor uses the NRCS Runoff Curve Number (RCN) to convert precipitation to a fraction of water that runs off a field. It is estimated that 50% of the total rainfall will not produce runoff. The Runoff factor has been adjusted by 0.5 to account for this reduction.

Precipitation is the 30-year average annual precipitation for each county divided by the constant 4.415 to convert inches of rain to million lb of water/acre. Precipitation for each county can be selected in the spreadsheet.

STP Runoff factor consists of total dissolved P concentration in runoff estimated from STP (6-inch depth) results from the Bray P-1, Mehlich 3, or Olsen test methods. The factors are the same for the Bray P-1 and Mehlich 3, and higher for the Olsen since the Olsen test extracts less P

P application factor is an estimate of the additional impact of recent P applications on STP. The value of the factor is zero when there was no P application since the last time the soil was tested.

3. Subsurface Drainage Component (Potential P delivered to surface water with subsurface drainage):

Precipitation x Flow factor x STP Drainage factor

Precipitation is the 30-year average annual precipitation for each county divided by the constant 4.415 to convert inches of rain to million lb of water/acre. Precipitation for each county can be selected in the spreadsheet.

Flow factor is determined by presence or absence of subsurface/substrata flow. If tiles or coarse textured soils are known to be present, then the flow factor is 0.1, it is assumed that the flow is 10% of the precipitation. If no the value is 0.0.

STP Drainage factor consists of two classes with a value of 0.1 if STP < 100 ppm Bray-1 or Mehlich-3 or < 60 ppm Olsen P, or a value of 0.2 if STP ≥ 100 ppm Bray-1 or Mehlich-3 or ≥ 60 ppm Olsen P.

The final Iowa P-Index score = ***Erosion Component + Runoff Component + Subsurface Drainage Component***

Iowa P-Index Delivery Risk Interpretation Classes

VERY LOW– 0-1 A field in which movement of P off site will be VERY LOW. If soil conservation and P management practices are maintained at current levels, impacts on surface water resources from P losses from the field will be small.

LOW – 1-2 A field in which movement of P off site will be LOW. Although the P delivery to surface water bodies is greater than from a field with a very low rating, current soil conservation and P management practices keep water quality impairment low.

MEDIUM – 2-5 A field in which movement of P off-site will be MEDIUM. Impacts on surface water resources will be higher than for the field with a low rating, and the P delivery potential may produce some water quality impairment. Careful consideration should be given to further soil conservation and P management practices that do not increase P delivery to surface water.

HIGH – 5-15 A field in which movement of P offsite will be HIGH. Water quality impairment will be large. Remedial action is required to reduce P movement to surface water bodies. New soil and water conservation and/or P management practices are necessary to reduce offsite P movement and water quality degradation.

VERY HIGH – >15 A field in which movement of P offsite will be VERY HIGH. Impacts on surface water resources are extreme. Remedial action is required to reduce P delivery to surface water. All necessary soil and water conservation practices plus a P management plan, which may require discontinuing P applications, must be put in place to reduce water quality impairment.

Sensitivity Analysis of the Iowa P-Index for Simulated Field Scenarios

Sustainable Environmental Solutions, Inc. (SES) developed and modeled several scenarios of land application fields to determine the critical factors influencing the P-Index values and rankings for the Iowa P-Index. All the scenarios were for soils with a texture of silty clay loam, silty clay, or clay loam. The conclusions reached were:

- Soil loss values, especially for row crop fields with little or no soil conservation practices, are the dominant factor in determining the P Index value and rating. In fact, once the soil loss values exceed 11 to 13 tons per acre, it is nearly a given that the field will rank in the "high" P Index category, regardless of soil P values. If, on the other hand, the soil loss can be brought down to tolerable levels for a row crop field (3 to 5 tons/acre/year), then soil P levels have a large effect on the P Index value and rank for a field. These fields may have up to 200 ppm soil test P and still be ranked as "moderate."
- If soil loss is minimized as in a pasture (or good hay ground) situation, soil P content can be high (>300 ppm) before the field will rank in the "high" P Index category.
- Distance to water has little effect on the rankings until the distance is 500 feet or less.