Phosphorus Losses in Surface Runoff and Tile Drainage –Ontario Experience

The challenge of keeping nutrients in the root zone year-around highlights the importance of multiple barriers with stacked/bundled BMP's to stabilize cropland and prevent runoff.

Patience is wearing thin in some communities because of water quality problems linked to the loss of crop nutrients from agricultural land and other sources. The city of Des Moines, IA, is moving ahead with a law suit against three highly agricultural Iowa counties that manage drainage districts traced to high concentrations of nitrates in the Raccoon River, a major source of drinking water for the city. Des Moines officials claim that tile drains should be regulated as point sources under the Clean Water Act.

Nonpoint pollution sources now make up the largest source of total phosphorus (P) leading to excessive algae growth and disruption of fisheries in Lake Erie. In 2014, a toxic algae bloom shut down the public water supply for Toledo, OH, and summertime bans on swimming and other recreational activities are common.

Much of the most productive farmland in Ontario, Michigan and Ohio is tile drained. Tile drainage creates a suitable environment for plant growth by removing excess water and improving infiltration and aeration. Tile drainage reduces runoff and increases water storage. While drainage has economic and environmental benefits, under some conditions excess nutrients from commercial fertilizers and livestock manure can quickly move to tile drains through preferential flow paths; cracks and fissures in the soil, worm holes, root channels and other macropores, and thereby escape from the field.

Dr. Merrin Macrae, Associate Professor at the University of Waterloo in Ontario, Canada, opened a conference sponsored by the Michigan Chapter of the Soil and Water Conservation Society and MSU Extension in East Lansing on March 4, *A Matter of Balance: Systems Approaches to Managing the Great Lakes Landscapes.* Her presentation, Phosphorus Losses in Surface Runoff and Tile Drainage from Agricultural Fields Using Multiple Conservation Strategies for Phosphorus Management, summarized the results of work with farmers in southern Ontario in tracking nutrient cycling and water quality impacts from surface runoff and tile drained lands to Lake Erie tributaries.

Southern Ontario farms are largely in corn/soybean/wheat rotations similar to many farms in Michigan and Ohio. Dr. Macrae's research group worked with several progressive farmers (ANSWERS group) and had help and funding support from the Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA) to establish year-around sampling sites to measure runoff of both overland flow and tile drainage. The soils were silt loam, clay or sandy loams. Soil test

phosphorus (P) averaged 14 ppm ranging from 5 to 25 ppm (Olsen) with a tile depth of 3 feet and spacing ranging from 30 to 45 feet. Various low disturbance tillage practices were used. Commercial P was subsurface banded, typically at planting time, and poultry litter was used at one location.

When are most nutrients lost?
In Ontario, precipitation is fairly well distributed throughout the year with no real predictable wet or dry periods, but runoff is highly seasonal. Very little runoff occurs during the growing season unless there is a huge storm; most rainfall is stored in the soil profile and is used by the crop. Most runoff occurs in the non-growing season. Typically, 80% of runoff occurred between October and June with most of that at snowmelt in March. Because P loss was proportional to runoff most nutrient loss occurred in the non-growing season with most losses during spring snowmelt. During the growing season nutrient loss was linked to runoff following heavy rainfall events so maintaining crop residue cover and other erosion prevention BMPs was important.

Nutrient loss from tile drains has come under close scrutiny in recent years. In Ontario, Dr. Macrae measured much higher P concentrations in surface runoff than in the tile drain effluent. Compared to tile drainage, surface runoff was a much 'hotter' source of P. At one site, surface runoff was only a minor contributor to the total runoff volume, but it was a major contributor to dissolved reactive phosphorus (DRP) loss. Tile drainage contributed most of the total runoff but overland flow carried most of the nutrients. Most of the total annual P loss was particulate P carried by sediment in runoff during snowmelt.

The timing of nutrient application and soil test P was important. When commercial P or poultry litter was applied in the fall autumn rains led to spikes in tile drainage P. Late fall and all applications on frozen ground should be avoided. Very early fall or spring applications carry less risk, particularly subsurface or banded applications.

Current BMPs
No-till cropping is associated with better soil aggregation and structure, but with little tillage nutrients can concentrate near the surface where they are at risk of loss to overland flow. No-till soils tend to have greater macropore development which can enhance rapid movement of nutrients to the tile drains. Periodic tillage may break the flow paths and mix the nutrients more evenly throughout the root zone and thereby reduce soil test P at the surface. Subsurface placement of fertilizer P will help reduce surface stratification.

Cover crops, buffer strips, grass waterways and other forms of vegetation to slow water movement and retain sediment are proven methods for reducing sediment and nutrient loss. There is some concern in northern locations that some winter-killed covers can release soluble P but the risk differs by species. Cereal rye, vetch and red clover overwinter well. In Michigan cover crops are often protected by snow cover and the soil is not often frozen when susceptible covers are killed so runoff losses may not be significant.

Manage the farming system
On a watershed basis, current estimates are that MI, IN and OH farmers in the Lake Erie watershed are losing about 1.5 lb/acre of P per year. Logic dictates that losses would be similar

in the Saginaw Bay watershed. The goal for Lake Erie is to reduce losses by about 40% to less than 1 lb/acre in the western basin. In Ontario, Dr. Macrae measured consistent field losses on the cooperating farms less than ½ lb/acre per year, even in wet years. The low losses were achieved with strategically low soil test P and subsurface banding or immediate (before rainfall) incorporation. Crop rotations, cover crops after wheat, residue management, rotational or minimum tillage after wheat, no nutrient applications in late fall or on frozen ground and the use of multiple, bundled BMPs held crop nutrients in the root zone for crop use.

Bottom line

The challenge of keeping nutrients in the root zone year-around highlights the importance of using multiple barriers with stacked/bundled BMPs to stabilize cropland and prevent runoff. Monitoring and sampling throughout the non-growing season, and particularly during snowmelt and early spring, is critical for truly understanding the timing and quantity of nutrient loss. Little runoff and nutrient loss occurs during the growing season; most runoff and nutrient loss occurs at snowmelt. Overland flow tends to be the 'hottest' source of nutrient loss so select BMPs that slow the water down. Avoid late fall nutrient applications and all applications on frozen ground. Spring applications carry less risk. Banding carries less risk than surface broadcasting, but when nutrients are broadcast they should be incorporated before rainfall because most loss occurs with the first rainfall events.

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