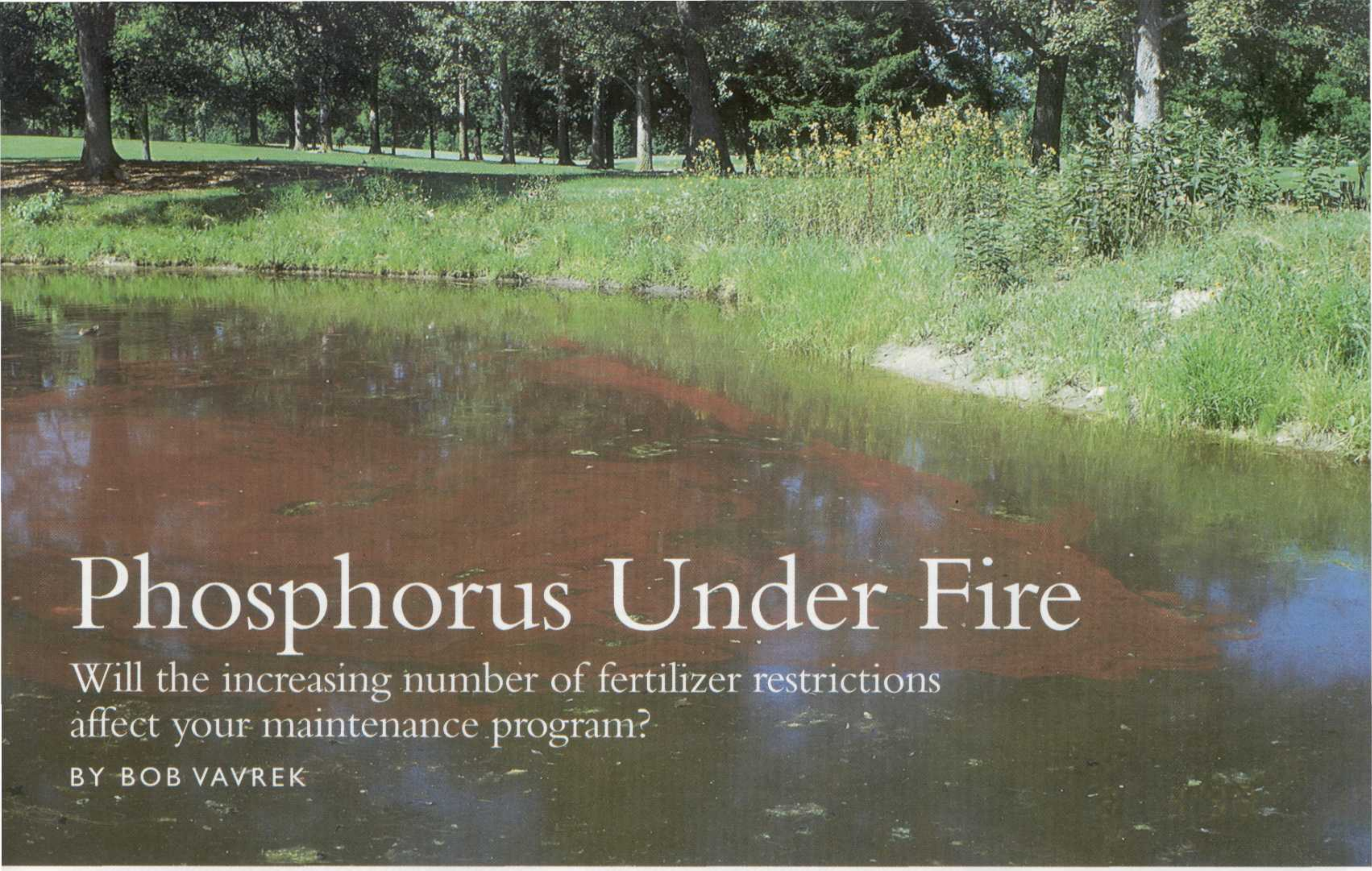

Phosphorus Under Fire

Will the increasing number of fertilizer restrictions affect your maintenance program?

BY BOB VAVREK

Turfgrass Science 101 . . . nitrogen (N), phosphorus (P), and potassium (K) are among the most important of the 13 mineral elements essential for plant growth. Elements required by plants in the greatest quantities are designated *major nutrients*. The dry weight of P (P_2O_5) in turfgrass clippings is usually less than 0.5%, in contrast to 3% to 5% for N and up to 5% for K (K_2O) (Turgeon, A. J., 1980). The relatively low P content in turf plants compared to N and K, however, should not diminish its role regarding healthy turf growth and development.

PHOSPHORUS — AN ESSENTIAL PLANT NUTRIENT

Phosphate is a key component of ATP (adenosine triphosphate), an energy-rich organic compound produced during the light reaction of photosynthesis. ATP is the energy currency used by plant cells for various metabolic processes, such as the synthesis of carbohydrates. You will find the highest concentrations of P where all the action takes place — primarily meristematic regions where new cells are produced. Phosphorus is also found in seeds, where it is essential for seedling development until the turf can develop a root system more capable of obtaining nutrients from the soil solution.

STARTER FERTILIZER — PLACEMENT IS THE KEY TO SUCCESS

Considering the exceedingly small size of a creeping bentgrass seed, for example, it comes as no surprise that the supply of seed-borne P is depleted quickly during establishment. Symptoms of P deficiency can rapidly develop during the grow-in unless an ample supply is available in close proximity to the shallow, immature root system. As a result, general recommendations for turf establishment include a pre-plant application of a high-P starter fertilizer at a rate of approximately 1 lb. of N. For most starter fertilizers, 1 lb. of N provides about 1.3 to 2 lbs. of P_2O_5, which becomes very important about 3 to 4 weeks after seeding when P reserves in the seed are exhausted.

Phosphate is a reactive anion that is relatively immobile in the soil. Soluble forms of P, such as monoammonium phosphate, react rapidly and form insoluble complexes with iron and aluminum under acid soil conditions and calcium under alkaline conditions. As a general rule of

Phosphorus from turf fertilizer is being blamed for accelerated eutrophication of surface water. As as a result, Minnesota and several counties/communities in other states have regulated the sale and use of fertilizers that contain this essential plant nutrient.

thumb, the only time it is unnecessary to apply pre-plant phosphorus is when the soil test value for P is already 2 to 3 times more than the amount recommended for established turf. For example, if your particular soil test deems 25 ppm of P to be adequate for established turf, then a pre-plant application of starter fertilizer is likely to be beneficial anytime the soil tests less than 75 ppm of P.

Reduced overall growth, narrow leaf blades, and dark green color are symptoms of moderate P deficiency. Soils in the upper Midwest with less than 25 ppm P (Bray-1) or 18 ppm P (Olsen) are considered to be phosphorus deficient. Under severe deficiency the leaf blades can turn reddish to purple color with tip discoloration.

A sign of the times . . . turf fertilizer advertised as being phosphate free.

THE PHOSPHORUS CONTROVERSY — A HISTORY LESSON

Based on the nature of P to be tightly bound to soils, this nutrient would appear to be an unlikely candidate for environmental concern. What factors have resulted in recent statewide restrictions on fertilizers that contain phosphorus in Minnesota and even more stringent regulations in Dane County, Wisconsin? Let's set the stage with information gleaned from an interesting U.S. Geological Survey publication regarding the history of P control measures in the United States. This comprehensive document is part of the National Water Quality Assessment Program initiated by Congress in 1986.

WHITER WHITES AND BRIGHTER BRIGHTS

Phosphorus concerns date back to the '50s, when synthetic detergents (powdered laundry soaps) were developed to replace bar soap, which was the primary cleaning agent used for clothes prior to WWII. Reformulated cleaning agents contained up to 15% by weight of P in the form of tripolyphosphate, a compound that removed hardness from water in the washing machines that were being utilized in an increasing number of households at the time. According to the review, at the peak of phosphate detergent use in 1967, the consumption of P for making laundry soap was about one-tenth the amount used for fertilizer.

Needless to say, a considerable amount of phosphorus was going down the drain into water treatment plants and eventually into rivers and lakes. The phosphorus concentration in raw wastewater-treatment-plant effluent nearly quadrupled from the 1940s to 1970, and over half the increase was believed to be caused by phosphates in detergents.

During the same period, synthetic fertilizer production and use increased significantly to keep pace with a growing population. Similarly, the increasing amounts of manure used to fertilize crops were being recycled into the environment.

A DEAD LAKE WAKES UP THE PUBLIC

Natural fresh surface water undergoes an aging process called eutrophication (eutrophic: from Greek and German meaning *well fed*). The process is associated with increased aquatic plant and algae growth, high nutrient content, a reduction in water clarity, and decreased dissolved oxygen content. Increased biological activity ultimately results in sedimentation as dead and decaying plant debris sinks and accumulates on the bottom of the lake or pond. In essence, surface water is transformed into a bog. Excessive inputs of P accelerate the eutrophication process of lakes.

By the end of the 1960s, a serious decline in water quality was documented for many major bodies of surface water, especially water adjacent to heavily populated areas of the eastern United States. The poor water quality of the Great Lakes, particularly Lake Erie, caused the public to stand up and take notice. Lake Erie was referred to as a *dead lake*. Massive blue-green algae blooms severely discolored water and gave drinking water a bad taste. Mats of filamentous algae littered the beaches and affected fish spawning grounds. The degradation of water quality had a serious effect on commercial fisheries. In earlier days, blue pike comprised up to 50% of commercial catches that sometimes exceeded 20 million pounds. The blue pike population crashed between 1954 and 1958 and never recovered. By 1983 it was designated an extinct species.

GOVERNMENT INTERVENTION

Public outcry about water pollution finally reached the politicians. The Joint Industry-Government Task Force on Eutrophication was established by Congress in 1967. The goal was to accelerate research in the hope of finding a suitable substitute for phosphates in laundry detergent that would have minimal impact on the environment. In 1970 a Congressional Committee recommended an end to the manufacture of phosphate detergents by 1972. No Federal legislation was passed, while Canadians took the first significant steps to address the problem. In Canada, phosphate levels in laundry detergents were limited to 8.7% in 1970 and further reduced to 2.2% in 1972.

In the United States, cities and states began to regulate phosphate detergents. In 1971, five cities in Illinois passed regulations to limit the amount of phosphates in laundry detergents. Since then, many states have enacted complete or partial detergent bans, particularly states on the east coast and adjacent to the Great Lakes. By 1994 the industry found it more cost effective to simply remove phosphates from all domestic laundry products instead of maintaining separate inventories of phosphate-free materials.

Interestingly, some states never regulated detergents and, in general, regulations only affect domestic detergents, not commercial cleaning agents or dishwashing detergent. However, a quick inventory of cleaning products from my bachelor apartment was made (quick because there just aren't that many to be found). All were designated *phosphate free* somewhere on the label, including the dishwashing detergent . . . an enlightening exercise, considering some unopened containers of products hidden under the sink were likely purchased back in the 1970s.

THE CLEAN WATER ACT

The Federal Water Pollution Control Act arrived in 1972. Commonly referred to as the Clean Water Act, the statute employs regulatory and non-regulatory tools to reduce point-source and non-point-source pollution of the nation's surface waters. Point-source pollution consists of effluent discharges from pipes directly into surface water. Non-point pollution sources include runoff from construction sites, agricultural erosion, feedlot erosion, and urban storm sewer discharge. Pollutants in runoff or drainage water discharges from golf courses would be considered non-point sources. Incidentally, the Clean Water Act does not address issues regarding groundwater pollution.

First, concerns regarding point sources of pollution were identified and addressed. Billions of dollars have been spent cleaning up pollutants from wastewater treatment plant effluent. Water

A thunderstorm can quickly transform a fairway into a river. Avoid making fertilizer applications to turf when heavy rainfall is in the forecast. On the other hand, be sure to water-in fertilizer applications as soon as possible to move nutrients off the grass and into the soil.

A narrow strip of unmowed turf or shoreline vegetation can provide an effective buffer zone between fairways/roughs and surface water. Buffer zones provide habitat for wildlife and help reduce nutrient loads into water during runoff events.

treatment facilities were upgraded to remove or reduce a variety of pollutants, which sometimes included treatments to reduce P concentration in effluent. Within a relatively short period of time, the serious problems regarding wastewater were addressed, particularly at treatment plants adjacent to the Great Lakes.

Since the late 1980s, the focus of the Clean Water Act has shifted to identifying and reducing non-point sources of pollution. It was a relatively easy task to identify and monitor the concentrations of pollutants that enter and leave a water treatment plant. However, identifying, monitoring, and reducing sources of non-point pollution were, and continue to be, a considerable challenge.

In the rural setting, non-point pollution from P includes agricultural soil erosion and manure disposal from concentrated animal feeding operations. In urban settings storm sewer effluent and fertilizer runoff from gardens and turf have been targeted as sources of P into surface water.

STATEWIDE REGULATIONS FOR THE LAND OF 10,000 LAKES

Lakes abound in Minnesota, particularly in the heavily populated Twin Cities area. It should come as no surprise that municipalities surrounded by lakes would develop various local ordinances regulating fertilizer use. A clean, pristine lake has much greater recreational use than a eutrophic lake choked by weeds and tainted by massive algae blooms. The first wave of P fertilizer use restrictions varied from community to community and resulted in considerable confusion for lawn-care professionals, homeowners, garden-center professionals, etc. After considerable debate, statewide fertilizer use restrictions are now in effect for the entire state of Minnesota (Rose, C. J., and B. P. Horgan, 2005).

Fertilizer restrictions beginning January 1, 2005, include:

- Only phosphorus-free fertilizer will be used on lawns across the state.

• Exception: phosphorus can be applied on golf courses when a person trained in a program approved by the Minnesota Department of Agriculture directs their fertilizer use.
• Exception: phosphorus can be applied on sod fields, which are considered to be a form of agricultural production.
• Exception: phosphorus can be applied during turf establishment or when it is based on soil or tissue tests; however, rates need to follow those recommended by the University of Minnesota and approved by the Minnesota Department of Agriculture.

Note that Minnesota has restricted, not banned, the use of P fertilizer. Somewhat more stringent restrictions exist currently in Dane County, Wisconsin, where the sale/display and use of P fertilizer are regulated.

WHAT FUELED THE FERTILIZER CONTROVERSY?

In essence, turfgrass fertilizer restrictions are a community response to actual or perceived concerns regarding accelerated, phosphorus-induced eutrophication of nearby recreational lakes. It didn't help the debate when it was discovered that 70% to 80% of lawn and garden soils submitted to the University of Minnesota Soil Testing Laboratory tested in the very high range for phosphorus. A similar scenario exists in Wisconsin, where many soils on lawns and golf course fairways test high for phosphorus.

Until the recent regulations took effect, there were few, if any, phosphorus-free commercial fertilizers for homeowners. Keeping the lawn green meant applying fertilizer each season, so the P content of the soil slowly, but surely, increased. There is little, if any, noticeable effect on turf quality where high soil P is present, unlike an obvious change in color or surge of growth that accompanies overzealous nitrogen inputs. Golf course turf managers have the option of phosphorus-free fertilizer. Unfortunately, with some exceptions, fertilizer regulations do not distinguish between home lawns and golf course turf.

Apparently ignored during the debate was the fact that P that reaches a lake in an urban setting can come from other sources besides turf fertilizer. For example, a watershed study in Minnesota that compared treatments of removing vs. not removing leaves from streets during fall and fertilizing lawns with P vs. P-free fertilizers showed that P from decaying leaves had a greater impact on nutrient loading than the use of P fertilizers (Shapiro and Pfannkuch, 1973).

Why regulate home lawns and golf course fertility programs instead of the vast acreage of agricultural land that obviously has greater potential for erosion and runoff than a dense stand of turfgrass? From the politicians' point of view — what do we regulate first, recreational P use or crop production? The answer should be obvious.

RESEARCH IS THE KEY

Politics aside, can P fertilizers from golf courses be found in leachate or runoff water? USGA-funded research shows that under rather worse-case scenarios, such as a 2" simulated rainfall event applied 4 hours after a fertilizer application, P can be found in the runoff water. However, much less P was found in the runoff when the fertilizer application was watered immediately into the turf — a standard practice employed by responsible turf managers (Shuman, L. M., 2002).

Make an extra effort to clean equipment in an environmentally responsible manner. Modern equipment-cleaning facilities are equipped with traps that separate grass clippings from waste-water, thereby reducing the nutrient load into storm sewers and surface water.

In the same study, P was found in the leachate of simulated sand-based greens in the greenhouse under a heavy irrigation schedule and large simulated rainfall event. Less nutrient leaching was found at lower irrigation rates. When the study was conducted outside using field lysimeters to more closely simulate actual greens, the amounts of nutrients found in the leachate were considerably lower than for the greenhouse experiments. The take-home message was to use less-soluble sources of P at light rates on sand-based greens, and, of course, don't overwater the putting surfaces.

In a perfect world, turf managers would be able to apply just enough fertilizer nutrients to supply the exact needs of the plants — no excess and no deficiencies. Judicious soil testing and tissue testing help us make more cost-effective and environmentally responsible choices regarding fertilizer inputs.

Then again, if the world were perfect we would all be able to eat just enough to maintain a constant, ideal weight . . . so it's obvious the world is not perfect. In fact, we apply fertilizer to the soil, where transformations occur and elements move in and out of dynamic equilibrium with the soil solution. Some of the nutrients are taken up by the roots and utilized by the turf; some are immobilized or transformed by soil microbes, and so on. Some nutrient loss through leaching and runoff is to be expected, and responsible management practices help keep these losses into the environment negligible.

Knowing the concentration of phosphorus in runoff or leachate is important because it helps fine-tune our management practices. More important, however, is the total load of P that reaches lakes near golf courses — a number considerably more difficult to determine. A trickle of water with a P concentration of 5 ppm that exits a drain tile of a green after a heavy rainfall event poses less risk of accelerated eutrophication than a stream flowing into the lake that has a P concentration of 2 ppm. The total load is a function of the P concentration and the volume of water that enters the lake.

A better view of the big picture can be seen in a study that measured the concentrations of nutrients upstream and downstream from two golf courses. Water was sampled on a regular schedule and after five heavy runoff events. There was no difference in the upstream and downstream levels of P concentrations found in regular sampling. Golf course 1 had a slightly higher P concentration in water downstream on a few occasions after runoff events. In contrast, upstream levels of P were always higher than downstream after all runoff events at course 2. The author suggests that the presence of a buffer strip along the stream at course 2 was the reason why water leaving the course had less P than water entering the course, even after heavy rainfall events. Long-term enrichment of streams associated with runoff from the golf courses was not found (Soli, A. M., and W. O. Lamp, 2004).

USGA-funded research to develop models for nitrogen and phosphorus runoff and leaching is being conducted currently at the University of Georgia. Buffer strips, nutrient losses from turf, and water quality monitoring are being studied at other universities as well.

SUMMARY — EASY DOES IT

Lighten up is a good attitude to take regarding phosphorus use. Soil test surveys indicate that many soils on golf courses and home lawns already have ample and often excessive supplies of P. Make an extra effort to obtain soil tests on a consistent schedule to monitor P levels, but avoid comparing test results between labs because P values vary according to the method of extraction.

The most important time to ensure adequate P is during establishment. Adequate soil test values for established turf may not supply enough P for shallow-rooted seedlings.

Apply light, frequent applications of P to sand-based greens and avoid overwatering to minimize loss of P through leaching. Water-in fertilizer applications immediately, but avoid making fertilizer applications when heavy rainfall events are forecast.

Eliminating unnecessary P use from your turf program will ultimately benefit the environment and the operating budget. Monitor nutrient levels throughout the course consistently and you'll be better prepared for any unexpected regulations down the road.

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