Evidence from turf research

Since these early studies, there has been much research on the contributions of turf fertilizers to nitrate present in ground water. This work was thoroughly reviewed in 1990 by A. Martin Petrovic at Cornell University and will not be repeated here. I will only comment that some preliminary studies on golf course greens which received relatively high rates of soluble nitrogen fertilizers and were extensively irrigated were found to leach substantial amounts of nitrate.

These were mostly sand-based greens which had little capacity to retain nitrogen and generally represented the worst case situation for nitrate leaching. A more realistic study was reported by Stuart Cohen and his colleagues in 1990. They studied four established golf courses on Cape Cod, Massachusetts, placing ground water monitoring wells up-gradient and on greens, tees and fairways. These were sampled monthly for nitrate over an 18-month period and generally failed to find nitrate-nitrogen concentrations in excess of 10 ppm. On one course, where nitrate-nitrogen was in the 10-30 ppm range, relatively high rates of nitrate containing fertilizers had been used. When these rates were reduced to 2-3 lbs N/1000 sq-ft (down from 5.5 lbs N), ground water nitrate-nitrogen levels decreased to less than 5 ppm.

In this study, the ground water was less impacted by other land uses so that in three of the four sites, up-gradient wells produced water which contained only 0.1-0.2 ppm nitrate-nitrogen. The authors of this report concluded that, while golf course fertilizers could elevate the nitrate content in well water, they rarely caused an increase greater than 10 ppm nitrate-nitrogen and this could be reduced by simple modifications in fertilizer management.

It should be noted that Cape Cod was selected for this study because it has extremely sandy soils of low organic matter content which overlay shallow aquifers. In other words, if ground water contamination from turf fertilization did not occur on Cape Cod, it probably would not occur anywhere. Research has pretty well confirmed this conclusion with the sole exception of some Southeastern locations where soils are equally sandy, there is even less soil organic matter and the annual precipitation is greater. Combine this with soils that rarely freeze and warm-season turfgrasses which are dormant during the winter, and significant nitrate leaching is commonly observed. In the northern and central states where cool-season grasses predominant and soils are heavier, significant nitrate leaching from reasonably managed turf is highly unlikely.

Field Tips

How to minimize nitrate leaching

by Dr. Richard Hull

While much is known about conditions which favor nitrate leaching from established turf, there is also a good deal that is not well understood. However, enough is known to formulate a few reasonably sound recommendations for minimizing nitrate leaching from turf. These practices are especially important if your turf is on a site over a shallow aquifer and preserving ground water quality is a concern.

Even without concerns over ground water quality, these suggestions are valid because they promote efficient nitrogen use by turf and that means less must be applied and money may be saved.

- Many small applications (0.25 to 0.5 lbs N/1000 sq-ft) will promote less nitrate accumulation in the soil and therefore, less leaching. This practice will also provide a more uniform fertility level and promote better and more consistent turf growth. This approach to fertilization also will allow you to use less expensive inorganic materials and urea. While more labor for application is required, it may be partially offset by less costly materials and an over-all reduction in amount used.

- New seedings and freshly sodded turf are especially prone to nitrate leaching until a root system becomes established. It is better to let the turf become somewhat hungry for nitrogen than applying much fertilizer during the first two to three months. If fertilizer is clearly needed (seeding on a poorly prepared low quality soil), apply the principle in small

Minimizing nitrate leaching from turf

Even though turf, fertilized or not, is among the land covers most protective of ground water quality, it still can be managed so as to reduce its nitrate release to the lowest levels possible. In the September 1994 issue of *Turf Grass Trends*, I discussed some of the conditions which contribute to nitrate leaching and listed some steps turf managers can take to reduce these losses. Those suggestions were made with a view toward maintaining turf with minimum use of nitrogenous fertilizers. The idea was to utilize nitrogen mineralized from soil organic matter as much as possible. Obviously if little nitrogen in used, little is likely to be leached from the turf-soil system. This approach, the practicality of which remains to be demonstrated, is only valid for established turf where large soil organic pools have accumulated. What about new turf established on a site devoid of organic matter and most plant nutrients? Can a minimum fertilizer nitrogen strategy work there? Probably not, and annual nitrogen applications of 3 to 4 lbs/1000 sq-ft likely will be necessary. When that much nitrogen is applied to young turf, some special precautions should be taken to minimize nitrate leaching.

The speed by which an extensive root system will develop is an important consideration in guarding against nitrate leaching. If the number of roots and their depth of penetration in the soil is limited, their capacity to absorb soil water nitrate will be low and the opportunity for leaching will be great. This was demonstrated recently by researchers at Ohio State University who compared nitrate leaching from 'Baron' Kentucky bluegrass turf seeded or sodded on May 1. During the following summer, soil water nitrate and potential for leaching was greater under seeded than under sodded turf. Nitrate concentration under both turfs was often greater than 10 ppm nitrate-nitrogen. In the autumn, soil water nitrate levels remained high (>30 ppm NO_3-N) but no differences between establishment method was evident. During the winter and from then on, soil water nitrate was consistently lower under seeded turf than under sodded turf. (See figure on page 8.) Throughout the second year after establishment, soil water nitrate-nitrogen under seeded turf remained below 4 ppm while that under sodded turf climbed to more than 10 ppm.

Apparently a sodded turf initially establishes roots more quickly than does a seeded turf but after two or three months the seeded grass produces the deeper more extensive root system which is better able to absorb soil nitrate. This difference in root system efficiency probably does not persist indefinitely but may be evident for two or three years. In any event, the method of establishment should be considered when designing a fertilizer program for new turf.

frequent applications. Sod normally is heavily fertilized before it is sold so, a sodded turf can go unfertilized for several months with no risk of thinning or injury. Irrigation is critical during turf establishment which means the opportunity of nitrate leaching is increased. Normal rules for estimating irrigation needs are less valid on poorly rooted turf which can access only the top inch or two of soil. Frequent light irrigation is best but a goodly amount of sound judgment is also useful. It may be better to tolerate a little nitrate leaching during the establishment period and insure a thick, vigorous, well rooted turf which will protect the ground water for many years.

- Young turf, past the establishment stage, will require more nitrogen than turf that has been in place for many years. It takes time to build the organic content of the soil. Once the organic matter level is high, its metabolism and turnover will provide much of the turf's nitrogen needs as was emphasized in the September *Turf Grass Trends* article. Before then, however, a vigorous turf is a veritable sponge for nitrogen and leaching potential is minimal. At that time, it is best to meet the nutritional needs of the turf and be less concerned over nitrate leaching.

- Injured and thin turf, especially late in the summer, is least able to absorb nitrate and thus is prone to nitrate leaching. However, the grass may need nitrogen, so frequent small applications is the approach to take. Treat such a turf much as you would if it were newly seeded. The similarities between a few seeding and a recovering turf are numerous and they should be treated similarly.

- Although fall fertilization has been recommended for many years as the mainstay of turf fertility management, concern over nitrate leaching has prompted greater attention to early spring and early summer applications of nitrogen. If grass is injured during the summer and needs to recover before cold weather sets in, light frequent nitrogen applications

periods of drought are not uncommon throughout most of the country, turf is often irrigated, especially when it is professionally managed. Excess irrigation is wasteful of water but it can also promote nitrate leaching. This was demonstrated clearly by A.J. Gold and W.M. Sullivan in a 1988 report from the University of Rhode Island. Established turf plots were fertilized at 0, 86.6 or 218 lbs N/acre/year using urea and flowable liquid ureaform applied on a schedule similar to that used by lawn care companies. One set of plots was irrigated to avoid drought stress and prevent percolation from the root zone while another set received 1.4 inches of irrigation each week throughout the growing season regardless of rainfall. Soil water leachate was collected by suction plate lysimeters placed at a depth of eight inches in the soil.

While the soil water nitrate-nitrogen concentrations collected over a two-year period never exceeded 5.6 ppm, the amount of nitrate-nitrogen leached from the root zone of overwatered high fertility plots averaged 28.5 lbs/acre. Similar plots irrigated only to correct moisture deficits leached 4.3 lbs NO_3-N/acre/year. This represented an annual loss equivalent to 13 and 2% of the nitrogen applied to over-watered and moderately irrigated turf, respectively. Even the moderately fertilized turf (86.6 lbs N/acre) lost 12 lbs N/acre when over-watered. Thus nitrate leaching can be significant when turf is overwatered even when soil water nitrate concentrations are not particularly high.

Problem or myth?

So what can we conclude from the research reported on nitrate leaching from turf, is there a problem or is it mostly myth? With the exception of some very sandy soils in high rainfall areas of the southeastern states, the probability of significant nitrate contamination of ground water resulting from even intensive turf management is extremely low. Obviously if a heavy nitrogen application (>2 lbs N/1000 sq-ft) is followed immediately by several inches of rain, significant leaching of nitrate will probably occur. However, if the nitrogen fertilizer was a slowly available organic form, even those circumstances would cause little nitrate leaching. For the first few months following turf seeding or sodding, nitrate leaching can occur. High applications of nitrate-containing fertilizers made during late summer or early fall if followed by heavy rain can also promote nitrate leaching. Thus, we cannot guarantee that nitrate will not leach from turf to ground water. However, if even casual precautions are taken to minimize the potential for leaching, turf is still one of the safest land covers available for ground water sensitive areas. ■

are in order. However, a vigorous healthy turf will retain its quality equally well if nitrogen is applied mostly during early and late spring with lesser amounts used in the late summer and fall. Emphasizing spring fertilization will minimize nitrate leaching from turf.

- Avoid nitrate salts. Because it is mined from geologic deposits, sodium nitrate (Chilean nitrate) is viewed by some as organically acceptable and therefore potentially less toxic. It is not very toxic but it is a nitrate source and will leach readily unless plant roots are in their most active phase when it is applied. Using sodium nitrate as an amendment to composts does not reduce its potential for leaching. All nitrate salts of potassium, ammonium and calcium should also be avoided because their nitrogen is already in the nitrate form and is immediately susceptible to leaching. If used, nitrate salts should be applied at less than 0.5 lbs N/1000 sq-ft at a time. Frequent light applications may be acceptable if the turf is actively growing. These salts are very likely to cause leaf burning and they are also most likely to injure turf if applied during hot and dry weather. A good rule in selecting nitrogen sources is to place as much chemistry between the nitrogen you apply and the nitrate which can leach. Organic materials, even urea, undergo several chemical steps before their nitrogen become nitrate. These materials will release nitrogen more slowly and pose less of a nitrate leaching problem.

- Retain clippings on the turf if that is compatible with its use. Grass clippings can contain 5% nitrogen which makes them a good nitrogen source. Research indicates that one-third of the nitrogen used by turfgrasses comes from clippings, if they are not removed. Thus, if clippings are retained on a well established turf, nitrogen applications may be reduced by one-third. Clippings are organic so their nitrogen is basically a slow release nitrogen source which has no nitrate leaching potential. Clippings of cool-season turfgrasses do not contribute to thatch accumulation. ■