Environmental Concerns for the Golf Superintendent

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Pesticides and fertilizers are as important to the golf course superintendent as they are in any other phase of agriculture. In the course of a year, golf course personnel are handling and applying reasonable amounts of these materials and should be aware of proper procedures and potential dangers: to themselves as well as to the environment.

Although factual data are very limited concerning the losses of nutrients and pesticides by runoff and leaching from golf courses, some information is available from which losses may be predicted. The results discussed here are based on research sponsored by the Green Section of the United States Golf Association. The efforts of the research are directed toward identifying possible pollution hazards on golf courses and collecting factual data so that the industry can defend itself from false accusations and take steps to eliminate potential problems before restrictive legislation is imposed.

On the golf course, the most intensive applications of fertilizers and pesticides are made to the greens. Although they usually account for something less than 1½ per cent of total golf course acreage, the permeable nature of the better constructed greens, the heavy application of water, and the subsurface drainage makes greens an area of concern. In certain situations, over 50 per cent of the nitrogen applied as a soluble fertilizer may be washed through the typical golf green within two weeks after application. Greens made entirely of sand lose even greater amounts of applied nitrogen. If slow-release or organic forms of nitrogen fertilizers are used, the nitrogen is not lost as rapidly and remains available over a much longer time. The slow-release forms suffer much less loss through leaching and resulting concentrations of nitrate-N in the drain water, are much lower than when soluble forms of nitrogen are used. On this basis, careful consideration should be given to the use of slow-release

Figure 1. Concentrations of nitrate-N in drain water from a golf green built to USGA specifications following one application of nitrogen fertilizer at a rate of 2 lb. N/1,000 sq. ft.

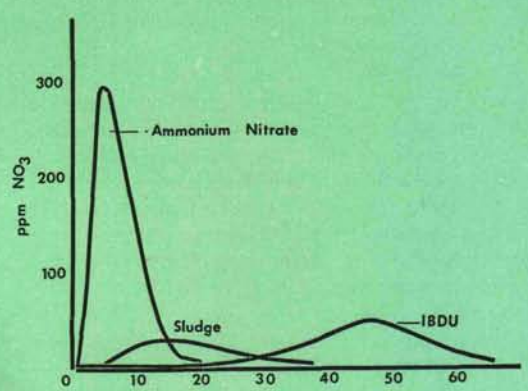
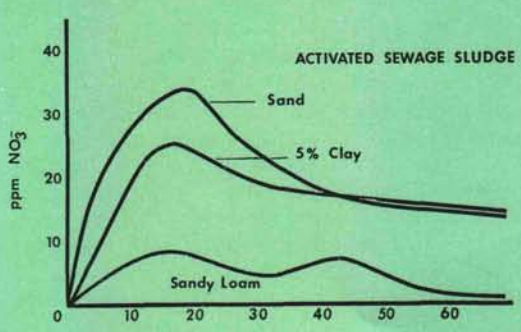


Figure 2. Concentrations of nitrate-N in drain water from golf greens constructed of three different soil mixtures after the application of sewage sludge at a rate of 12 lb. N/1,000 sq. ft.



forms of nitrogen fertilizer. Applications should be scheduled regularly so that a continuous level of release is maintained. If inorganic or soluble nitrogen forms are used, they will be most effective and efficient if applied on a light but frequent basis. Typical nitrate loss curves are illustrated for three N-sources and three soil types in Figures 1 and 2, respectively.

Whenever possible, the drainage lines conducting water from the greens should spread the water over gently sloping land. They should not lead to water courses. The prevention of loss of nitrate will not only reduce pollution hazards, but will also result in more efficient utilization of fertilizers.

Much of the loss of fertilizer in runoff is associated with soil erosion. The nutrients are carried with the soil particles and deposited in low areas and reservoirs. Management practices should be utilized at all times to minimize soil erosion. The problem is particularly acute during the construction and the establishment of grass. Whenever possible, all tillage should be done immediately prior to planting. On slopes and contours the use of sod or mulches will help reduce losses associated with soil erosion.

Undoubtedly some pesticides, including herbicides, insecticides, and fungicides are also lost through leaching and runoff. Pesticides containing the heavy metals mercury and arsenic have been studied at Texas A&M University for leaching losses and residue hazards in golf greens and fairways.

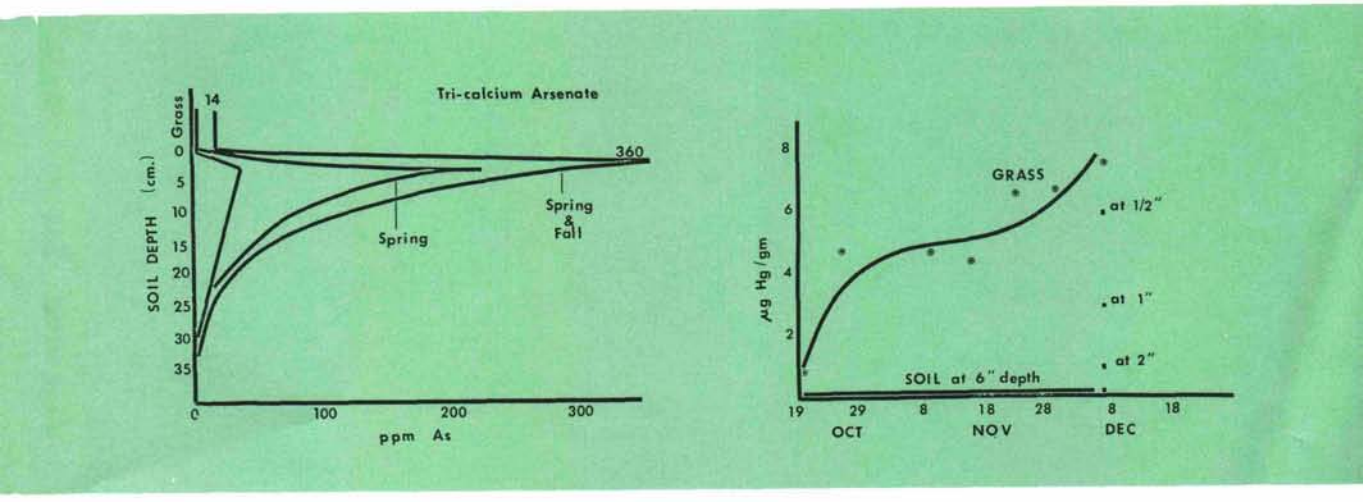
The old belief that "if a little will work, a lot will work much better" definitely does not apply to these pesticides. Large applications of these compounds not only increase the leaching losses and residue hazards but also interact to become toxic to some desirable grasses. Recommended rates of application should always be followed and then used only when necessary.

In soils comprised entirely of sand, arsenic is leached quite readily through the profile. Organic matter added to the sand reduces leaching losses considerably; but, the addition of as little as 5 per cent of clay loam soil to the mixture reduces arsenic losses to only a trace (Table 1). In fairway turf, repeated applications of arsenicals such as tricalcium arsenate result in the accumulation of arsenic in the surface two inches of soil, but very little arsenic is leached below the rootzone of turfgrasses (Figure 3). Thus, the arsenicals remain at the site of application unless grass clippings are removed. The grass clippings from turf grown on soil treated with arsenicals contain significant amounts of arsenic residues. Disposal of such clippings would best be accomplished by spreading them on or incorporating them into the soil. These clippings should not be composted as the arsenic would accumulate and would be taken up by the plants when the compost is utilized. If arsenic concentrations are high enough to damage the grass, the addition of superphosphate or a phosphorus containing fertilizer will reduce plant uptake of arsenic.

Another heavy metal, mercury, has received widespread attention as an environmental pollutant. Mercurial fungicides have been very effective against many disease organisms attacking turf. For this reason, we examined the fate

Figure 3. Arsenic residues at various soil depths after six years treatment with tricalcium arsenate. Spring and Fall treatments received a total of 10.5 and 20.5 lbs. of tricalcium arsenate, respectively.

Figure 4. Mercury residues in soil and grass samples taken from a golf green following three months treatment with a mercurial fungicide at recommended rates of application, College Station, Texas.



of mercury following the application of a mercurial fungicide to golf greens. Mercury reacts very similarly to arsenic in that it is rigidly tied up in the surface layer of soil; and, unless excessively high rates are applied, only trace amounts are leached through a golf green profile (Table 2). Grass roots readily absorb the mercury and may accumulate very high mercury concentrations. In some cases where the soil was found to contain 30 ppm mercury in the top two inches, grass roots in that soil contains 90-565 ppm mercury (Table 3). Grass leaves from the same soil contained relatively low mercury concentrations, 15-45 ppm (Table 3). Where mercury concentrations are high due to an error in application, or to spills, the addition of sulfur or a sulfur-lime mixture will help reduce the hazards of mercury toxicity and reduce the levels of mercury residue in grass clippings.

When inorganic arsenicals and mercury are applied to the same soils, plant uptake of mercury is significantly higher than when arsenic is not present in the soil. For example, where mercury alone was present, concentrations of 300-600 ppm mercury were found in grass roots and 15-30 ppm in leaves; but, where mercury and arsenic were present, 1,200-2,000 ppm mercury were found in grass roots and 60-100 ppm in leaves (Table 2). Although grasses can tolerate these levels of mercury, the composting of any clippings removed from such areas should be discouraged. Neither should such grass clippings be dumped in lakes, streams or creeks. Heavy metal residues remain in the soil several years after application, and grass clippings will show their presence for a similar time period.

Pesticides containing heavy metals are not the only materials used on golf courses. Chlorinated hydrocarbons, organo-phosphates and carbamates are also used as insecticides. Numerous other organic compounds are frequently used to control weeds and disease organisms. Most of these materials present similar residue hazards, but not for the duration of the heavy metals pesticides. Precautions should be followed during the storage, application and disposal of all pesticides, and grass clippings from treated areas should be treated accordingly.

The disposal of pesticides and fertilizer containers present special problems. Although the government has not yet detailed specific recommendations for disposal of pesticide and fertilizer containers, the following suggestions are the best available at this time. First of all, whenever possible, pesticides should be bought in containers not larger than five gallons. Smaller containers are easier to handle and easier to dispose of than larger, bulky containers. A second advantage is that if a leak develops, less of the material will be lost, and this possible source of pollution will be minimized. A third practical consideration is that with our rapid changing regulations, one will not get stuck with a large quantity of a suddenly illegal pesticide.

Care should be taken to completely empty all pesticide and fertilizer containers. A Canadian report indicates that an average of 2.7 per cent of pesticides remain in the container after the user considered it empty. To cut down on this loss, containers used to store liquid materials should be rinsed after they are emptied and the rinse water should be added to the spray tank before the final water is added to bring it

Table 1. Arsenic residues in drain water from golf greens constructed of different sand, organic matter and soil mixtures after one application of tricalcium arsenate at a rate of 3 lbs/1,000 sq. ft.

Weeks after treatment	ppm Arsenic in drain water*				
	100% sand	90% sand 10% O.M.	85% sand 10% O.M. 5% clay	80% sand 10% O.M. 10% clay	loamy sand
0	.001	.001	.001	.001	.005
1	.001	.005	.001	.001	.030
2	1.0	.010	.005	.005	.030
3	1.5	.025	.037	.075	.020
4	2.3	1.4	.030	.025	.050
5	1.7	1.5	.125	.055	.005
6	0.9	0.7	.175	.030	.005

*According to the 1967 Federal Water Pollution Control Administration the maximum permissible level of arsenic in public water supplies was 0.05 ppm.

up to volume. Sacks containing powdered and granular materials should be cut open carefully so that the material can be poured out directly without contents getting between the layers of paper making up the sacks. All sacks should be stored in cool dry places so that the materials do not cake and can be easily dumped out of the bags. All tops, lids, and bungs should be kept in place when the contents are not in use.

After containers are completely empty, they should be crushed and punctured. This is particularly important to prevent people from using them for other purposes. Children, for example, have been known to use discarded plastic containers for canteens.

The containers should be kept isolated from general trash and transported to and properly disposed of in approved landfills. Such landfills should meet minimum specifications which have been approved by the government, and in particular should be located away from water bodies and ground water and should provide 10 feet of soil between the bottom of the pit and bedrock. Materials disposed of in such landfills should be covered daily, and after the pits are filled, a four-foot layer of soil should be applied. In all cases, pesticide containers must be treated with respect. They are not just ordinary trash, and should never be carelessly discarded.

As in any form of agriculture, the proper storing, handling, application and disposal of fertilizers and pesticides on the golf course will provide us all with a safer and better environment.

Table 2. Mercury residues in grass, soil and drainage water from golf greens following weekly application over a 3-month period of a mercurial fungicide at recommended rates, College Station, Texas.

Days after first treatment	ppm Mercury		
	Grass	Soil*	Drain water
0	0.001	0.01	0
10	0.7	0.1	0
20	4.8	0.1	0
30	4.5	0.1	0
40	6.6	0.1	0
50	7.6	0.2	0
70	12.0	1.0	0
90	15.0	1.5	0

*Soil samples were taken at a depth of 6 inches. Samples taken at shallower depths showed higher concentrations of mercury.

Table 3. Mercury residues in bermudagrass turf grown on golf greens with different levels of mercury and arsenic added to the soil.

Mercury conc. in soil (ppm added)	Mercury (ppm) Arsenic conc. in soil (ppm added)					
	0		30		120	
	Roots	Leaves	Roots	Leaves	Roots	Leaves
0	1.2	0.4	0.9	0.5	2.8	0.7
30	90.5	2.3	490.0	14.5	565.0	45.7
120	174.4	2.3	900.0	21.7	1900.0	135.9