SOLVING A DISPOSAL DILEMMA

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While obtaining my Masters of Science Degree at the University of Massachusetts, I wrote the following article which generally describes the research I conducted over a two year period. I worked under the guidance of Richard Cooper, who is an associate professor of Turfgrass Science at the University of Massachusetts. The material originally appeared in the February 1993 issue of Golf Course Management and is presented here with permission.

Sewage sludge is the nutrient-rich semisolid material created during biological and physical treatment of wastewater from homes and industry. Currently, municipal sewage sludge production in the United States is about six million dry tons per year. That is equivalent to 47 pounds of dried sludge for each person in the U.S. Disposal of increasing amounts of sludge in an environmentally acceptable manner has become a major challenge for many cities and towns.

There are many ways in which to dispose of sewage sludge. Disposal of sludge in landfills is presently the most common disposal method in the United States. Landfill capacity is decreasing, however, and many existing facilities are expected to reach maximum capacity within 10 years.

Another popular disposal option is incineration. During 1988, incineration was used to dispose of about 16 percent of the country's sewage sludge. But construction costs, a large fossil-fuel requirement and pollution-control regulations make incineration an expensive option. Also, neighborhood opposition to incinerators and landfills makes permitting and site-selection difficult.

A third disposal option, ocean dumping of raw sewage sludge, has obvious environmental drawbacks and was banned in the United States last year. It is now illegal to ocean dump sewage sludge of any type.

Given the drawbacks associated with the traditional methods of sludge disposal—as well as declining availability of those options—interest in exploring beneficial land disposal of sludge has increased during recent years. As a result, an increasing number of cities are building facilities capable of processing sludge into compost or fertilizer products.

This is not a new idea. The city of Milwaukee has produced the activated sludge fertilizer, Milorganite, since 1926. In the Northeast, Boston has recently completed construction of a facility to process sewage sludge from the city and nearby towns that is producing about 30 tons of pelletized fertilizer per day. Output from the facility is expected to increase to 170 tons of pellets per day by the year 2000. Baltimore, New York and other cities also are currently building facilities that will generate sludge-based fertilizer.

In addition to generating a potentially beneficial fertilizer material, pelletizing greatly reduces the volume of sludge needing disposal. For example, by 1999 the Boston facility will be producing 1.38 million gallons of liquid sludge per day. That amount could fill 69 railroad tank cars. Dewatering the liquid to semisolid sludge cake (about 75 percent water) would reduce the volume to be disposed to about 50 railroad cars. After drying at 800° F to 900° F, the daily production would be reduced to an amount that would fill only 10 railroad cars.

In addition to greatly reducing volume, production of biologically digested, heat dried sludge fertilizer also destroys harmful bacteria and minimizes odor problems while producing a useful product high in organic matter. Because sludge contains nitrogen and phosphorus, as well as lesser amounts of potassium and micronutrients, it can be used as a fertilizer for turf areas.

However, sludge can also contain appreciable amounts of undesirable elements such as arsenic, mercury, cadmium, chromium, nickel and lead. The type and concentration of these elements in a particular sewage sludge is directly related to the amount contributed to the sewage system by its local industry. Sewage treatment plants are required to routinely monitor the heavy metal content of their sludge to assure that acceptable levels established by state and federal environmental protection agencies are not exceeded.

Sludge-based fertilizers are perhaps the most highly regulated type of fertilizer on the market, largely because of the realization that they contain heavy metals. Many other fertilizers used on turfgrass, however, also contain heavy metals, but are not required to meet the stringent quality-control standards that sludge-based materials must meet.

It is interesting to note that fertilizer derived from leather tankage material, for example, may contain chromium at levels greater than 15,000 ppm compared to sludge-based fertilizers which typically contains less than 100 ppm chromium.

(Continued on page 9)

Table 1.

EPA Pollutant Limits For Selected Elements In Sludge-Based Fertilizers.

Arsenic	Cadmium	Chromium	Copper	Lead	Nickel	Zinc	Mercury	Molybdenum	Selenium
					ppm				
41	39	1,200	1,500	300	420	2,800	17	18	36

One part per million (ppm) is equivalent to one second in 32 years.

(Continued from page 7)

Table 2.
Fertilizer Products Used In The Study.

Product	Nitrogen
Hagerstown (5-2-0)	Heat-dried sewage sludge
Milorganite (6-2-0)	Heat-dried sewage sludge
Ringer Turf Restore (10-2-6)	Hydrolyzed poultry feather meal, blood meal, wheat germ and bone meal
Urea (45-0-0)	Synthesized from ammonia and carbon dioxide

Fertilizers derived from ironite (mined in from pyrite in Arizona) have been found to contain more than 20,000 ppm arsenic compared to less than 10 ppm in sludge-based fertilizers. Rock phosphate mined to manufacture superphosphate for blended fertilizers can contain cadmium levels around 100 ppm, while sludges typically contain less than 10 ppm cadmium.

Golf courses and other turfgrass areas offer large potential for utilization of sewage sludge. Turfgrasses require many of the nutrients normally present in sludge while providing an area for disposal not subject to grazing by animals or production of food crops for human consumption.

Although there is likely to be an increase in the amount of sludge-based fertilizer applied to turfgrass in the future, additional information regarding its potential environmental impact is needed to increase its acceptance in the market place.

In an effort to learn more about the environmental impact of sludge-based fertilizers, research was initiated at the University of Massachusetts during 1991 and is still in progress. Fertilizers being evaluated are slow-release, natural-organic materials including: Hagerstown sludge (5-2-0), a commercially available material that is characteristic of the type of sludge-based fertilizer that cities are likely to produce in the future; Milorganite (6-2-0), a widely used heat-dried sewage sludge; and Ringer Turf Restore (10-2-6), a byproduct of the poultry industry.

All products are applied at 2 lbs. N/1000 ft2 in May and August to stimulate a medium-maintenance approach suitable for fairways or home lawns. The Hagerstown sludge is also being applied at rates higher than normal, twice yearly at 4 lbs. and 6 lbs. N/1000 ft2, to determine possible turf injury and leaching of nitrates and heavy metals. Products are compared to a program using urea 1 lb. N/1000 ft2 applied four times per year and a non-fertilizer control. Because research results were similar for both 1991 and 1992, only the 1991 data are discussed.

During 1991, Hagerstown sludge applied at 2 lbs. N/1000 ft2 provided visual quality similar to both Milorganite and Ringer Turf Restore applied at equivalent rates. Hagerstown sludge applied at rates as high as 6 lbs. N/1000 ft2 improved quality with no discoloration evident. For typical conditions, however, 2 lbs. to 4 lbs. N/1000 ft2 would be recommended.

Visual quality in response to both urea and Ringer fertilizers was initially better than either sludge material. This is due to the soluble nature of urea and the readily available nitrogen and proteins in the Ringer Fertilizer.

Pelletized sewage sludge initially releases nitrogen more slowly from its complex organic compounds, but typically provides acceptable visual quality for a longer period than quick-release nitrogen sources. Turfgrass clippings were collected every two weeks during 1991 to assess plant growth. The clippings showed that Hagerstown pellets applied at 2 lbs. N/1000 ft2 provided growth similar to Milorganite and Ringer Turf Restore applied at equivalent rates. Initially, urea applied at 1 lb. N/1000 ft2 provided more growth than either sludge fertilizer. Beginning in mid-July, however, Hagerstown sludge provided growth greater than urea applied at 1 lb. N/1000 ft2.

Soil water samples were collected after every substantial rainfall or at least every two weeks during 1991 and 1992 to assess nitrate leaching. The maximum allowable level of nitrate in drinking water according to federal standards is 10 ppm. Nitrate leaching from applications of Hagerstown sludge, Milorganite and Ringer Lawn Restore products applied at 2 lbs N/1000 ft2 were similar to nonfertilized plots during 1991. Rarely was the soil solution nitrate level greater than 1.0 ppm. Even following application of Hagerstown sludge at 6 lbs. N/1000 ft2, average nitrate concentration was only 4 ppm, well below the 10 ppm guideline.

One might expect that adding nitrogen would result in increased nitrate levels in soil water. It seems, however, that the additional growth spurred by the fertilizer results in greater uptake of nitrogen so that, in most instances, soil water nitrate is not greatly increased.

The soil water under fertilized plots also was analyzed regularly to monitor potential heavy-metal leaching. Hagerstown sludge and Milorganite applied at 2 lbs. N/1000 ft2 resulted in soil water concentrations similar to non-fertilized plots.

In fact, soil solution concentrations of boron, cadmium, chromium, manganese, molybdenum, lead and zinc never exceeded 0.1 ppm under plots treated with Milorganite or Hagerstown sludge applied at rates as high as 6 lbs. N/1000 ft2. Even when a substantial rainfall occurred soon after

(Continued on page 11)

Figure 1

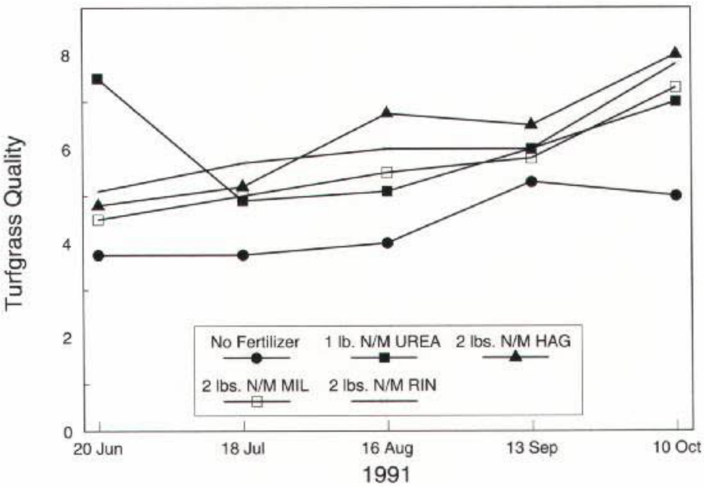
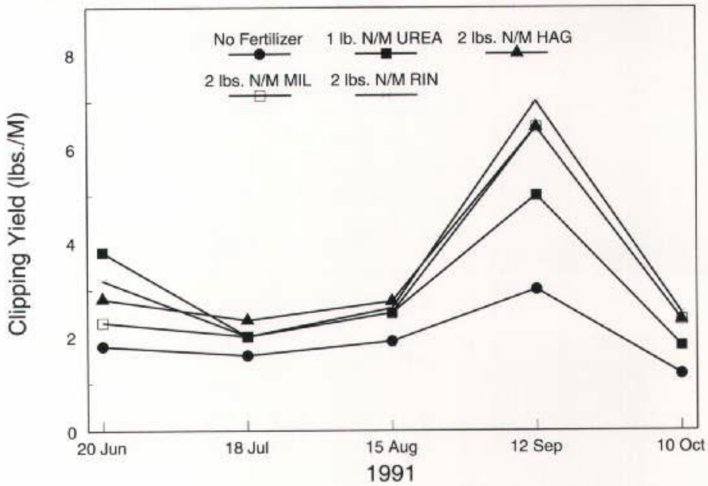


Figure 2



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application, pelletized sludge applications in our studies did not threaten groundwater quality.

An additional concern associated with sludge application to plants is that elevated levels of heavy metals might accumulate in leaf tissue and ultimately be consumed by animals or humans. Although this concern is not as important for turfgrass as for food or forage crops, clippings were nonetheless analyzed to monitor heavy-metal uptake from sludge applications.

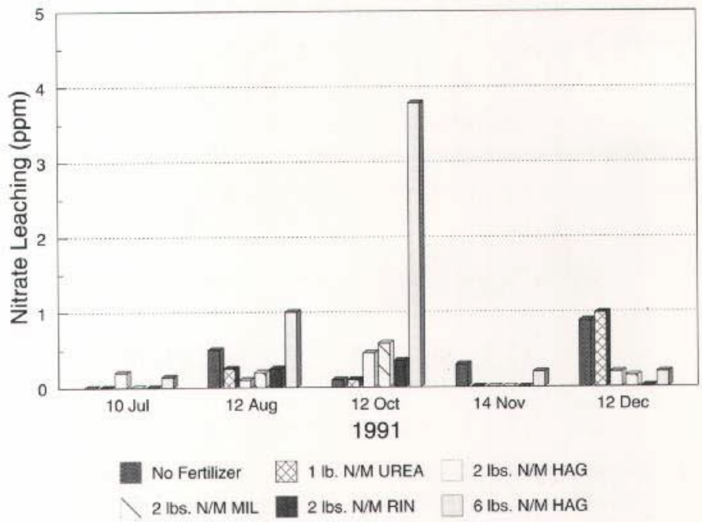
Concentrations of aluminum, cadmium, chromium, iron, lead, molybdenum, nickel and zinc in the leaf tissue of sludge-fertilized plots were similar to nonfertilized plots. Only boron and copper (essential micronutrients) were present in concentrations greater than in nonfertilized turf. However, the concentrations of boron and copper found were within concentrations typically reported for healthy turfgrass.

One of the greatest barriers to widespread acceptance of sludge as a fertilizer is the stigma associated with the use of waste product. Although the sludge-based fertilizers may have a slight odor, they are safe materials rendered free of pathogens by microbial digestion and heat treatment during the pelletizing process. They bear little relation to the materials from which they came except for chemical content.

Unfortunately, it is difficult to shed the negative perception associated with a product called "sewage sludge." Because of this, a more contemporary term, bio-solids, is gaining increased usage and acceptance within the industry. After all, wouldn't you rather apply bio-solids to your turf than sewage sludge?

Our work to date, as well as work by other researchers,

Figure 3



indicates that pelletized sewage sludge can serve as a beneficial turfgrass fertilizer without resulting in adverse environmental impact. These materials can be used alone or as a component of a blended fertilizer product to provide a longer nitrogen response than quick-release, water-soluble fertilizers.

In addition to the many environmental benefits provided by golf courses and other turfgrass areas, the potential for beneficial reuse of sewage sludge as a fertilizer is yet another positive attribute. Intelligent incorporation of sludge-based materials into a fertilization program can help reduce the nation's waste stream and relieve some of the existing burden on landfills and incinerator facilities.