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TURFGRASS TRENDS

RECYCLED WASTEWATER

Recycled Wastewater Instigates Different Responses in Turfgrass, Trees and Soils

By Yaling Qian

As the population of Colorado's Front Range continues to grow, increased use of recycled wastewater (RWW, or effluent water, is viewed as one of the approaches to maximize the existing water resource and stretch Colorado's urban water supplies. While Colorado is famed for its mountains covered with snow, that does not necessarily translate into unlimited use of fresh water for golf course or landscape use.

Based on data from the Department of Public Health and the Environment's Water Quality Control Commission, there are about 10 permitted recycled wastewater facilities in Colorado that can treat and deliver about 56 million gallons of effluent water daily for reuse purposes. We conducted a survey of managers at six sites — including five golf courses and one landscape park — that use recycled wastewater.

Survey results indicate that cost is not the driving force for landscapes to use RWW. Rather, the availability and reliability of the water were rated as the two main reasons for using RWW for irrigation.

Since 2003, research was conducted at Colorado State University with two objectives:

1) to assess variability of chemical properties of recycled wastewater in the Front Range of Colorado; and

2) to evaluate landscape soils and plants that are currently under recycled wastewater irrigation.

Understanding the responses of plants and soils to recycled wastewater irrigation and identifying proper management practices are critical to the long-term success of this practice.

Water quality

Recycled wastewater samples were collected from irrigation ponds and sprinkler outlets on landscape sites. Water testing results of about 50 RWW samples collected from six landscape sites were reviewed for suitability in landscape irrigation based on irrigation water quality guidelines (Westcot and Ayers, 1985).

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The average electrical conductivity (EC) of over 50 recycled wastewater samples from six reuse sites was 0.84 dS/m (deci-Siemens per meter, which is the same as mmhos/cm (millimhos per centimeter) and the range was 0.47 dS/m to 1.32 dS/m. Both are measures of salinity or electrical conductivity. An electrical conductivity higher than 0.75 dS/m indicates the water can impose negative effects on salt-sensitive plants. Periodic leaching of salts is required to mitigate the potential salinity problem.

Adjusted sodium absorption ratio (SAR) of recycled wastewater from reuse sites ranged from 1.6 to 8.3. Based on the interactive effect of salinity and sodicity on soil infiltration and percolation, most of the water samples collected showed slight to moderate effects on soil infiltration and permeability (Fig. 1). Long-term and continued use of water with a high-adjusted SAR will lead to a reduction of soil infiltration and permeability. Additional management (such as a calcium product topdressing or amendments and frequent aerification) is needed to mitigate these effects.

One of the other concerns of recycled wastewater irrigation is the presence of high levels of particular ions (sodium, chloride, and boron) that are toxic to some trees and shrubs. With sprinkler irrigation, sodium and chloride frequently accumulate by direct adsorption through the leaves that are moistened. Sodium and chloride toxicity could occur on sensitive plants when their concentrations in irrigation water exceed 70 milligrams per liter (mg/L) and 100 mg/L, respectively. The average sodium concentration of over 50 water samples collected was 99 mg/L, ranging from 30 mg/L to 170 mg/L. The average chloride concentration was 95 mg/L. Chloride leaches easily through the soil profile and chloride toxicity to turf and landscape plants should be minimal if soil is well drained and salts are regularly leached. However, if the sites have poor drainage, soil percolation is impaired or limited. Or if a shallow water table is present, chloride applied over time can accumulate to a toxic level.

In all cases, the water samples met or exceeded the regulations in regard of *E. coli* count as defined in the state regulations, therefore the water is suitable for landscape irrigation.

Soil

To assess recycled wastewater irrigation on the long-term changes of soil, we compiled soil test data from landscape sites that were near metropolitan Denver. Among these sites, six had been irrigated exclusively with domestic RWW for four, 13, 14, 19 and 33 years, respectively.

The other six with similar turf species, age ranges and soil textures had used surface water (average EC = 0.23 dS m^{-1}) for irrigation.

Our results indicated that soils (sampled to 11.4 cm) from sites where RWW was used for at least four years exhibited 0.3 units of higher pH and 200 percent, 40 percent, and 30 percent higher concentrations of extractable Na, B, and P, respectively (calcium, boron and phosphorus). Compared to sites irrigated with surface water, sites irrigated with RWW exhibited 187 percent higher EC and 481 percent higher sodium adsorption ratio (SAR) of saturated paste extract. However, extractable magnesium (Mg) was reduced by 15 percent ($P < 0.005$).

Comparison of soil chemical properties before and four or five years after RWW irrigation on two golf courses also revealed the following findings: a) 89 to 95 percent increase in Na content; b) 28 to 50 percent increase in B content; and c) 89 to 117 percent increase in P content at the surface depth (Qian and Mecham, 2005).

Plants

Generally, turfgrasses had a good appearance, showing salinity damage only on a few sites with poor drainage, heavy soil structure or shallow water table. However, chronic decline of conifer trees were often observed under RWW irrigation.

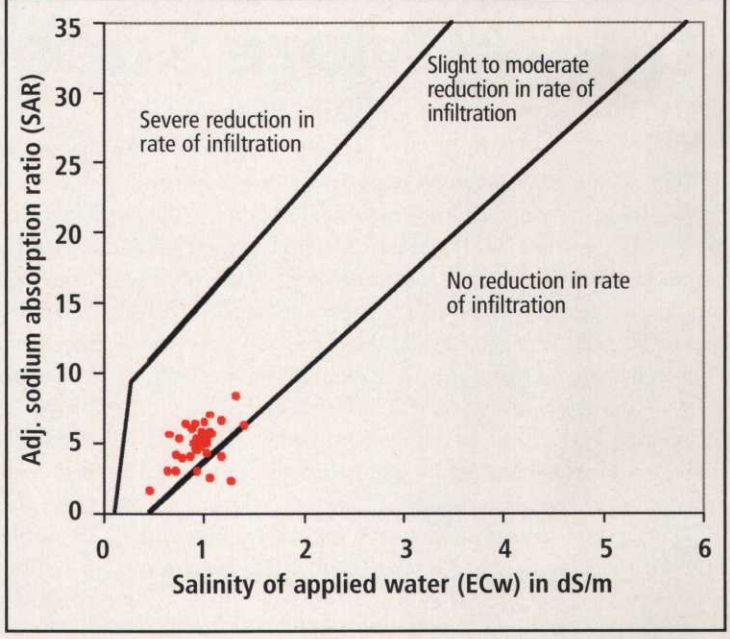
Ponderosa pines grown on sites irrigated with RWW for five years to 33 years exhibited 10 times higher needle-burn symptoms than those grown on sites irrigated with surface water (33 percent versus 3 percent). Tissue analysis indicated that ponderosa pine needles collected from sites receiving RWW exhibited 11 times greater Na^+ concentration, two times greater Cl^-, and 50 percent greater B concentrations than samples collected from the control sites.

Stepwise regression analysis revealed that the level of needle burn was largely influenced by leaf tissue Na^+ (positively charged sodium) concentration. Tissue calcium level and K/Na (potassium/sodium) ratio were negatively associated with needle burn symptoms, suggesting that calcium amendment and K addition might help mitigate the needle burn syndrome in ponderosa pine caused by high Na^+ in the tissue (Qian et al., 2005).

The project indicated that both problems and opportunities exist in using RWW for landscape irrigation. The use of recycled wastewater for irrigation in urban landscapes is a powerful means of water conservation and nutrient recycling, thereby reducing the demands of freshwater and mitigating pollution of surface and ground water. However, potential problems associated with recycled wastewater irrigation exist. Salts (especially the relatively high Na^+ and high EC) in the treated wastewater were associated with needle-burn symptoms observed in ponderosa pines subjected to RWW irrigation.

The significantly higher soil SAR in RWW-irrigated sites compared to surface water-irrigated sites provided reason for concern about possible long-term reductions in soil hydraulic conductivity and infiltration rate in soil with high clay content, although these levels were not high enough to result in short-term soil deterioration. This information is useful to landscape planners and managers to determine what should be monitored and what proactive steps should be taken to minimize any negative effects during planning and managing landscapes receiving recycled wastewater.

FIGURE 1



The above chart represents relative rate of water infiltration as affected by salinity and adjusted sodium adsorption ratio of irrigation water (Adapted from Ayers and Westcot). The dots are the data points of water samples collected from Colorado water reuse sites.

Understanding the responses of urban landscape plants and soils to recycled wastewater irrigation and identifying proper management practices are critical to the long-term success of the water reuse practice.

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Fertigation Finds Favor Among More Superintendents

By Peter Blais

Fertigation is getting more popular because it's getting less intricate, golf course superintendents say.

Superintendent Dan Pierson, who has used fertigation for several years, says his peers have a better understanding of the technology's efficiency as well as its environmental friendliness than they did than just a few years ago. Pierson has used fertigation at his course, the Wilmington (Del.) Country Club, since 1997. That's when the club installed a DGT-Volmatic fertigation system. DGT-Volmatic is a Denmark company specializing in nursery and greenhouse fertigation.

"The system has been a fantastic tool to assist us with nutrient application," said Pierson, who installed the system back then for about $25,000.

As more superintendents understand the technology and trust it, they are looking at fertigation as a way to deliver nutrients to their golf course's turf.

Fertigation systems generally have three to five tanks of fertilizers and nutrients, according to an article by John Plantholt on the New Mexico State University Web site (weather.nmsu.edu/Teaching_Material/SOIL456/Fertigaton/fert.htm). The largest tanks contain some combination of nitrogen, phosphorus and potassium. Smaller tanks often hold liquid iron and/or other minor-element nutrients. Occasionally, pesticide tanks are part of the system, although superintendents are frequently hesitant to fertigate pesticides because of environmental concerns.

Installing fertigation into existing irrigation systems is fairly easy and inexpensive. Liquid fertilizer tanks are tied into the main irrigation lines. An injection pump is wired to the control panel to monitor water flow along with fertilizer application rates. Control valves allow multiple tanks on the same system. Fertilizers can be applied separately or combined for a specific blend.

According to the Plantholt article, fertigation offers several benefits, including: Applications can be targeted to specific areas; less equipment is used; and fertilizer is applied into the soil, where it will be most effective. This means superintendents can apply fertilizers at lower rates, which can be cost-effective and specific to the turf's needs.

Irrigation layouts are generally divided into greens, tees and portions of fairways, allowing superintendents to fertigate various areas differently. If a certain zone needs a boost of a particular nutrient, the superintendent can target that area and ignore others. Computer controls regulate the injection of fertilizer and water flow so precisely that application rates are lowered. Properly timed applications can also keep liquid in the top few inches of soil and lessen the chance of nutrients leaching into groundwater or waterways.

"With micro-feeding through fertigation, tests have proven that nutrient in an aqueous solution measured in parts per million and introduced more frequently in smaller amounts can be utilized at efficiency rates upwards of 90 percent," Pierson says.

Fertigation virtually eliminates the need to use vehicles to apply nutrients, mitigating compaction caused by equipment travel, lowering equipment-operating expenses and reducing labor. Superintendents can even apply chemicals following a heavy rain without worrying about turf damage caused by vehicle traffic.

Fertigated nutrients penetrate directly into the soil and roots, meaning lower rates can still be effective in yielding turf density, quality and heartiness. And with today's directional sprinklers, less overcast ends up in surrounding lakes, woods, fields or roadways than might occur using mechanical spreading equipment with human operators.

"Other benefits are very clear," Pierson says. "Application at night eliminates interruption of other activity, whether it be play or work. There is no added disruption from supplemental water necessary either to wash product from the plant leaves or to initiate dilution for plant availability.

"Grow-ins, either at original construction or at the time of renovation, can be helped immensely by eliminating much of the equipment needed for nutrient application," Pierson adds. "And the safety factor is absolute. It is virtually impossible to burn with fertigation. Even if a sprinkler were to stick on all night, as we have all seen at one time or another, the worst effect is a darker green and not a deadly brown."

Potential downsides

Fertigation does not completely eliminate spreader applications, sources say. For the greatest benefit, courses should be in an area where irrigation is necessary at least once a week. On golf course greens, there are also times when an application of a special blend or

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PHOTO 1

Fertigation zones near lakes, streams and ponds must be implemented with great care to avoid contamination.

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supplement is needed. In this case, a fertigation tank of this mix may not be practical.

Irrigation systems must be carefully aimed not to throw nutrients into environmentally sensitive areas, such as streams, ponds or naturalized fescue areas, says Mike Stachowicz, superintendent of Dedham Country and Polo Club in Westwood, Mass. Older fertigation systems might not be sophisticated enough for today's ecological concerns. Throwback irrigation heads must be directed away from lakes, and an adequate buffer zone between the irrigation edges and nearby waterways must be present.

Stachowicz had fertigation when he was superintendent at The Ranch in Southwick, Mass., prior to relocating to Dedham several years ago. Back then there were myriad fertigation companies and a staggering number of computer-control options. Like Pierson, he feels the technology has become simpler.

"There seem to be fewer of the high-tech systems out there now," Stachowicz says. "Superintendents want to be able to go to the pump house and monitor tank levels themselves. The trend seems to be toward the less-technical systems."

Fertigation is more prevalent on Southern courses where the turf needs nutrients year-round and the soil is generally sandy, sources say. About 90 percent of Southern golf courses fertigate in some form.

Users offer useful tips

When he was superintendent at The Ranch, Stachowicz learned he could save money by making his own fertilizer blends from raw materials.

"I prefer to buy agricultural-grade materials, mix them with my own water and then put them out through the fertigation system, or even with spray tanks like I do here at Dedham," he says. "It's more work, and you might end up with clogged nozzles on occasion."

Stachowicz says he recently purchased a filtration system to pre-filter all fertilizers before putting them in spray tanks.

"That takes time, but I want to make my fertilizer go as far as it can," he says. "I've managed to cut the fertilizer budget in half here [Dedham]. It was $40,000 a few years ago. Now it's down closer to $20,000."

Pierson says his DGT-Volmatic system includes a pH sensor making it "acid ready." That means the system has no element that is either sensitive to acid corrosion or heat and can inject acidic products of almost any form that may be desired to correct water-quality problems. He says other superintendents are impressed with the feature.

Like Pierson and Stachowicz, Tom Grimac, superintendent of Tavistock Country Club in Haddonfield, N.J., is sold on fertigation. He likes that fertigation offers the opportunity to apply very low rates of fertilizer on a regular basis, a formula that is great for the health of both turf plants and the environment. It also allows superintendents to inject micronutrients and wetting agents, which increase the efficiency of irrigation water.

"You can supposedly reduce water use 30 percent with the proper use of wetting agents," he says.

Grimac also notes the labor and material savings fertigation provides with light and frequent fertilizer applications. "It is a very efficient use of fertilizer," he adds.

Pierson believes most superintendents are at least seriously considering fertigation as an option when they install a new irrigation system.

"I was very happy with the fertigation system 11 years ago when we first installed it," he says. "I'm an avid proponent of the technology and our system to this day. It is a very effective and safe way to feed a golf course."

Peter Blais is a freelance writer from Monmouth, Maine.