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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.

QUICK TIP

Plants have certain requirements that are needed for sustained health. Naturally these can be applied, or, in areas where deficiencies occur, supplementation by man is needed. Water, carbon dioxide and fertilizers are a few examples. Research efforts in irrigation focus on the efficiency of applied water through automated systems. Proper irrigation is providing the plant with sufficient water to maintain turgidity and cooling through transpiration. Excess amounts cannot be utilized by the plant and can cause other issues, such as shallow root systems. The same holds true with fertility programs and the importance in efficient feeding while minimizing losses.

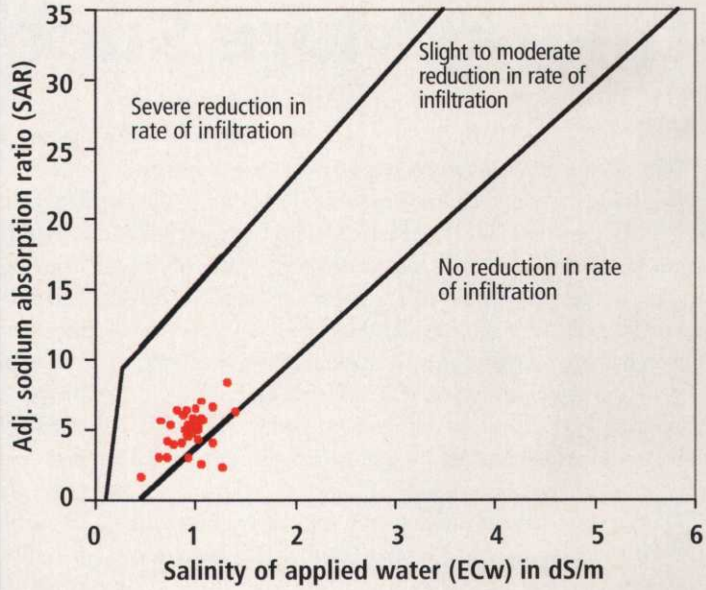
Ponderosa pines grown on sites irrigated with RWW for five years to 33 years exhibited 10 times higher needle-burn symptoms than those grown on sites irrigated with surface water (33 percent versus 3 percent). Tissue analysis indicated that ponderosa pine needles collected from sites receiving RWW exhibited 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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